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Contents.

	PAGE
A Liaison with Industry	495
Australian Premier Inspects Foundry	496
I.B.F. Secretariat	496
Foundry Trades' Equipment and Supplies Association	497
Applying Science in the Foundry	499
The Care of Files	504
"Non-Ferrous Foundry Practice"	505
Foundry Statistics	507
A New Roll-Surface Pyrometer	507
Personal	507
The International Foundrymen's Convention at Detroit	508
Institute of British Foundrymen	509
Lancashire Foundrymen Discuss Malleable Castings	510
Trade Talk	514
Iron and Steel Markets	516

Forthcoming Events.

DECEMBER 10.

Institution of Engineering Inspection:—Ordinary meeting in London. "Portable Steel Structures of Large Span," Paper by Major H. N. Wylie, B.Sc.

Junior Institution of Engineers:—Lecturette in London. "The Determination of Temperature in Cylinders of Internal-combustion Engines," Paper by C. E. Foster.

DECEMBER 14.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "Blast Furnace Gas and its Uses," Paper by T. P. Colclough, M.Sc.

Institute of British Foundrymen.

DECEMBER 11.

Lancashire Branch (Junior Section):—Joint meeting at Manchester. "Cast Iron in Engineering," Paper by E. L. Rhead, M.Sc.

West Riding of Yorkshire Branch:—Ordinary meeting at Bradford. "Some Further Experiences with Jolt Ramming," Paper by A. L. Key.

Wales and Monmouth Branch:—Ordinary meeting at Cardiff. "Pearlit Cast Iron," Paper by J. G. Pearce.

DECEMBER 14.

Burnley Section:—Open discussion, at Burnley.

DECEMBER 17.

Newcastle-on-Tyne (Junior Section):—Annual smoking concert.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.
PRESIDENT, 1926-27: Vincent C. Paulkner.
49, Wellington Street, London, W.C.2.

LIST OF SECRETARIES—

General Secretary: T. Makemson, 38, Victoria Street, London, S.W.1.
Birmingham: F. K. Neath, 16, Sarehole Road, Hall Green, Birmingham.
Sheffield: R. Village, "Bircholme," Dronfield, near Sheffield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
London: H. G. Sommerfield, Charterhouse Chambers, Charterhouse Square, London, E.C.1.
Newcastle-on-Tyne: Colin Gresty, 101, Queen's Road, Monkseaton, Northumberland.
East Midlands: H. Bunting, 17, Marcus Street, Derby.
West Riding of Yorkshire Branch: S. W. Wise, 183, Moorside Road, Eccleshill, Bradford.
Wales and Monmouth Branch: J. J. McClelland, M.I.Mech.E., Druslyn, Bishops Road, Whitechurch, Glam.
Middlesbrough: N. D. Ridsdale, 3, Wilson Street, Middlesbrough.

Welsh Engineers' and Founders' Association.
Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

Foundry Trades Equipment & Supplies Association.
Secretary: K. S. Bridges, Avenue Chambers, Southampton Row, London, W.C.1.

A Liaison with Industry.

We have previously commented in these columns on some of the difficulties in the way of the regular absorption of technically-trained students in ironfounding. It would not be fair to suggest that there is a prejudice against university men in general. The truth is that the idea of employing a university-trained assistant is no more natural to many ironfounders, and particularly those running small foundries, than the idea of seeking a job in a foundry is natural to the average student. It is also true that a certain proportion of the students with a university qualification produced each year by the academic system are temperamentally unsuited to business life. Any employer who has the misfortune to give such a man a start is apt to be prejudiced against all his kind for a long time to come.

The real trouble, however, is that the employer hesitates to offer a raw graduate a staff position, even at a low commencing wage, because he has no opportunity of assessing the man's value until a year or so has passed, thereby risking a failure just at the point where it would do most harm to a growing organisation.

Few foundries are large enough and conscious enough of the need to have a formal apprenticeship system whereby students can be given experience during a probationary period before being employed on the staff. How then can the necessary personal contact be established between a university and industry so as to facilitate this absorption? We suggest that a university might well set up committees for its applied science departments, on which representatives of the industry might be invited to sit, together with representatives of the university or technical college. Such committees would, of course, be advisory only, but we believe that very considerable advantages would accrue.

Business men would learn something of the nature of the work undertaken in the course and the characteristics of the students, and, through the personal contacts resulting, arrangements for the practical training of students would be facilitated. The university would retain full power of control over its internal affairs, and yet get rid of that aloofness which characterises many such institutions. The connection between the university and the works should be as close as that between the medical schools and the hospitals. We believe that such advisory committees have been tried, with conspicuous success, by the Manchester College of Technology and Sheffield University.

Not the least important advantage would arise from the appropriate professor having at his disposal the advice of those actually concerned with the industry, and practical assistance in connection with equipment and plant. Maintaining any laboratory on up-to-date lines is an expensive business, and such expert assistance would be of considerable value to the university, in addition to creating confidence in its work.

We trust that this year's increased demand for university students will hasten rather than retard the adoption of some such suggestion. At the present time far too many students go into laboratories, whereas the university should aim at directing the bulk rather than the minority of men into executive positions, in administration, in buying and selling, in costing, in manufacture, as well as in research, technical control, and development work. To do this adequately would ultimately mean training five or ten times the present number of students.

Australian Premier Inspects Foundry.

Mr. Stanley Bruce, the Australian Premier, and Mrs. Bruce had a novel experience when they were conducted over the foundry of Messrs. John Wright & Company—a constituent firm of the Radiation group of gas appliance makers—at Aston, Birmingham, on the afternoon of November 30. For his tour through the foundries Mr. Bruce wore a white smock and furnace gloves.

In welcoming the Prime Minister, Mr. H. James Yates, chairman of Radiation, Ltd., said that it was peculiarly appropriate that the visit should be made at a time when the development of Empire trade was being so vigorously encouraged with Great Britain. The gas appliance industry, which was one of the largest and most vital to our industrial prosperity, had made immense progress during recent years, particularly in respect of such modern comfort as gas-heating and gas-cooking, and, so far as the Radiation group was concerned, had firmly established itself not only in this country but overseas, including Australia.

"It is a matter of pride to us," said Mr. Yates, "that both there and elsewhere in the British Dominions we are emphatically an Empire trading concern. Our order books might well be labelled 'on account of trade within the Empire,' and in this connection I should like to say how greatly we appreciate the preference that your country gives to goods made in the Home Country, in comparison with the goods of other countries.

A Large Foundry Industry.

"Radiation, Ltd., possesses through its constituent companies as many as sixteen works, covering altogether over a hundred acres, and employing over 10,000 workpeople; and we are having to make further extensions to our works, for which purpose we have recently acquired an additional sixty acres of land.

Mr. Bruce, in a brief reply, heartily reciprocated Mr. Yates's expression of goodwill in regard to the development of inter-Empire trade, and declared that Australia was very desirous of encouraging British manufacturers in preference to the manufacturers of foreign countries.

The Premier showed the keenest interest in the various processes. Having first cast an inscribed paper weight as a souvenir, he then proceeded, with the aid of a workman, to pour molten metal from a heavy, two-handled ladle and cast a gas grate. Both feats were heartily cheered by the workmen. The castings were then presented to him by Mr. Yates, and when completed in an art metal finish the gas grate will be dispatched overseas to adorn the Premier's Australian home.

MR. BRUCE, THE AUSTRALIAN PREMIER, AS A FOUNDRYMAN.

Publication Received.

The Staveley Company's Magazine. (Vol. I. No. 1.) Published by the Staveley Coal & Iron Company, Limited, Chesterfield. Price 4d.

This monthly magazine has replaced the "Staveley Works Magazine," of which six issues have been published. We prefer the new title, as it helps with the impression that everybody from Sir W. Bird, the chairman, down to Dutton, who apparently is a prolific goal scorer for the works football team, are all definitely part of this great industrial concern, employing some 14,000 hands. We congratulate Mr. G. Redford on his effort, which consists of 24 illustrated pages and cover. Undoubtedly the most interesting contribution is an anonymous one entitled "Economy and Production," and we hope the Editor will have more articles from this author.

Mr. Berresford's appreciative note on the late Mr. Chas. P. Markham is the best pen picture of his character we have so far encountered, especially when contrasted with the lop-sided obituary notices which appeared in a portion of the London daily Press.

Obituary.

MR. WILLIAM MCLEOD, of the Blackburn Foundry, Dunfermline, died on December 1, after only a few hours' illness. It appears he left the foundry shortly after 5 o'clock, having been superintending operations in connection with a large casting, when a few minutes after he reached Blackburn House he was stricken with cerebral hemorrhage. He succumbed before 10 p.m. Mr. McLeod served his apprenticeship in iron-moulding at Grantsbank, where he afterwards became a foreman. In 1878 he began business on his own account, with his brother, at Whitemyre Foundry. The place becoming too small, he started the now well-known Blackburn Foundry, specialising in castings for paper-making and sugar-refining machinery. The Blackburn Foundry, which can turn out castings up to 30 tons, is noted in the principal engineering shops in Edinburgh and Glasgow. Mr. McLeod, who was 83 years of age, is survived by six sons and three daughters. Mrs. McLeod died seven years ago.

I.B.F. Secretariat.

Until December 16, correspondence for the general secretary should be addressed to 38, Victoria Street, London, S.W.1, and afterwards to John Street Chambers, John Street, Manchester. Mr. Makemson has, on his appointment as General Secretary, resigned his position as honorary secretary of the Lancashire Branch.

IT IS ANNOUNCED that Messrs. Morris Motors, Limited, have received an order from Australia for 10,000 cars.

Foundry Trades Equipment and Supplies Association.

First Annual Dinner.

The first annual dinner of the Foundry Trades Equipment and Supplies Association was held at the Engineers' Club, London, on Friday, December 3, 1926. Mr. V. C. Faulkner (President), was in the chair, and among those present were:—Mr. Wesley Lambert, Dr. Walter Rosenhain, F.R.S., Dr. H. Moore, Mr. H. G. Somerfield, Mr. H. Winterton, Mr. R. J. Shaw, Mr S. G. Bagshaw, Mr. A. S. Beech, Mr. K. W. Bridges, Mr. Barrington Hooper, Mr. W. O'Keefe, Mr. J. G. Pearce, Mr. C. A. Eberle, and Mr. J. W. Gardom, whilst many of those present brought guests.

Proposing "The Foundry Trades Equipment and Supplies Association," MR. WESLEY LAMBERT said he could not propose this toast otherwise than with feelings of great pleasure when he realised that all the members of the Association were business men of great integrity, and that the slogan which the Association was going to see upheld was clean business, honest advice and value for money. The Association was quite an infant in years, but it was a very healthy infant and of very robust parentage. That there was need for such an Association was made clear by the immediate success which it had attained, by the number of its members, and by the amount of cash which he understood it had available. (Laughter.) He hoped it would flourish and build up worthy traditions unhampered by unsolicited advice and forebodings and warnings. Another reason which gave him great pleasure in proposing this toast was that it gave him an opportunity, as Chairman of the Technical Exhibits Advisory Committee, of expressing the gratitude of himself and his colleagues on that committee for the hearty co-operation and assistance rendered to the committee by the Association. The committee was very grateful for being afforded the opportunity of having a technical exhibit at the Exhibition held in the Royal Agricultural Hall, and in that expression of gratitude he wished also to include the names of Mr. Bridges (senior) and Mr. Kenneth Bridges, for the work they had done in that connection.

Business Trend Curves.

The CHAIRMAN, replying to the toast, said that to preside over a gathering such as this required a good deal of tact, because there were among its members a good many clashing interests. Strictly speaking, he ought not to be occupying the chair at all, because he was a professional man and not a business man. However, as President, he wished to say how much the Association appreciated the work of the Technical Exhibits Advisory Committee, over which Mr. Wesley Lambert had so ably presided. That committee met on many occasions, and the Association felt proud that the National Physical Laboratory, through the courtesy of Dr. Rosenhain, together with the Sheffield University, the Birmingham University, the Woolwich Research Department, and the British Cast Iron Research Association, had co-operated in this work, and it was also very grateful to the many foundry firms such as Frazer & Chalmers and Ealing Park, represented by Mr. Bartlett and Mr. Shaw, which loaned interesting samples to help to make the technical exhibit the wonderful success it was. He was specially pleased that the Dominions were represented at that dinner. They had their old friend Mr. O'Keefe, for instance. They hardly knew whether he was an Australian or not, but they had to believe him when he said he was, although he had now almost acquired a Birmingham accent. Then there was Mr. Eberle from Owen Sound, Canada, and he came over with the very encouraging report that the British foundry equipment firms cannot do any business over there. (Laughter.) They were all very sorry to hear that, of course, but it was to be hoped that through the development of the Association that position would be altered, and that business with the Dominions would be very considerably increased. As an indication of what the Association intended to do for the trade he mentioned that it had been decided to prepare a business trend curve, so that the individual members could see whether they were getting their proportion. Such a curve would be the finest trade barometer that could possibly be devised, because there was no industry which was such a true reflex of trade as a whole as the foundry trade, inasmuch as it was part and parcel the textile, electrical and, indeed, all phases of engineering, the mines, the railways, shipping and every branch of industry generally. Therefore, such a curve should not only represent the trend of sales in the foundry industry but would also represent the trend of industry generally. Such a curve would necessarily have to be based on information supplied by members of the Association. The curve, when constructed by their energetic secretary, Mr. Kenneth Bridges, would be at the disposal of the members of the Association. In conclusion, the President thanked Mr. Lambert for the manner in which he had proposed the toast, and those present for the cordial way in which it had been received.

Overseas Greetings.

MR. H. WINTERTON, proposing "Sister Organisations," said he had just visited America, and was pleased to bring with him the greetings of the American Foundry Trades Equipment and Supplies Association. At a dinner of that organisation he had told them that immediately on his return to England he hoped to see at any rate the members of Council of the Association, and our American colleagues impressed upon him that they would like him to convey their greetings. In doing so, he wished to acknowledge, at the same time, the wonderful hospitality which had been extended to him by the American foundry people whilst he was in America. The Association, as had been said, was a very young one, but it was hoped that it would become more and more useful as time went on. At the same time, he did not quite agree with the President that there were clashing interests in the Association. The interests of one member of the Association should surely be the interests of all—(hear, hear)—and he felt quite sure that the more they met together the better they would understand each other, and would carry on very much on the lines of the sister organisations of whom it was his privilege to speak in proposing this toast. They had with them that evening Dr. Walter Rosenhain, Director of the Metallurgical Department of the National Physical Laboratory, and it was his name which was coupled with this toast. There was also present a representative of the Cast Iron Research Association in Mr. Pearce, and, in addition, there were also several prominent members of the cast-iron trade. All were given a hearty welcome, and they would all learn, from a booklet shortly to be sent out by the secretary, that the Foundry Trades Equipment and Supplies Association does not intend to have anything to do with the fixing of prices. It would exist entirely for the technical advancement of the trade.

Wide Scope of Foundry Equipment.

DR. WALTER ROSENHAIN, in responding to the toast, said he felt in a little difficulty, because he was not quite sure which sister organisations he was supposed to represent. Really, however, there was no difficulty, because he had the honour of belonging to a considerable number of organisations, ranging from small committees to large institutions and associations, and every one of them, from the most highly scientific to the most practical, would appreciate the cordial expressions of goodwill which had been voiced that evening, and would wish him, if they knew that he were for the moment in the difficult position of their representative, to voice their cordial reciprocation of the goodwill that had been expressed towards them by the Association. Any Association that was formed for the technical advancement of some branch of industry or business must be

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regarded in the most friendly way by all other organisations, technical or scientific, because the technical advancement of an industry like the foundry trade could not fail to be of value in helping forward the work of other organisations. We all hang together far more intimately than we sometimes realised, and, therefore, goodwill and good feeling all round was eminently to be desired and cultivated. It was for this reason that he welcomed the opportunity of expressing, on behalf of any number of other Associations, cordial goodwill on their part. When he had said this he had said almost all he had to say; but there was, perhaps, just one thing he might say. Foundry equipment was perhaps a wider term than even some in the trade realised. Foundries were sometimes thought of merely as large, dirty places in which big things were made, but quite recently he had come across a type of foundry in which hardly ever more than one of a kind was made. No two were exactly alike, but a casting process was employed. He referred to dental plates. (Laughter.) He asked them to look, for a moment, and imagine the most fantastic and nightmarish way of doing a difficult job, which was the way the dentist did it; it was amazing to see the process which, from the metallurgical point of view, was highly successful, yet the devices, if tried to be used in large work, would be literally "Heath Robinsonish." There was a field for the foundryman. (Loud laughter.) However, that was merely one of the outlying aspects of the foundry industry which offered openings for business. The work of this Association, however, if it carried out the aim mentioned of improving the technical side of the industry, must help in this direction. The exhibition that was held during the summer—unhappily, under somewhat unfavourable circumstances—struck him as being an attempt in the right direction, and it was to be hoped that that attempt would be pursued and carried farther in the future, under happier auspices. But there was need for much more than that. Many of the sister associations to whom goodwill had been expressed in this toast were research associations. The Cast-Iron Research Association, represented by Mr. Pearce, had been mentioned, and there was also the Non-Ferrous Metals Research Association and others carrying on kindred work. These Associations were really something more than sister associations, and they were associations in which the Foundry Trades Equipment and Supplies Association should take more than a sisterly interest. That interest should run to something like very definite collaboration and support, and he believed that that had already been given, and was further contemplated, at any rate, in one direction. If that were done, then the Association was to be highly congratulated upon it. The foundry industry was one in which there are a great many small concerns, and these small concerns could never themselves carry on the extensive and fundamental researches which the industry was so urgently in need of. The industry was literally crying aloud for this work to be done, and it was only by co-operative effort that these demands could be met in order that the industry can face the tremendous advances that are being made abroad, and not only on the other side of the Atlantic. In meeting this competition we need every ounce of assistance we can get, and that assistance could best be obtained by collaboration with the sister organisations which are working in the same direction. We need not be disheartened, however, if only we worked together on the lines indicated.

The final toast, "The Visitors," was proposed by MR. A. S. BEECH, who extended a cordial welcome to the visitors at the first annual dinner of the Association. Several speakers had referred to the fact that the Association was young, but it must be agreed that it is very vigorous and virile. Mr. Lambert had referred to its parentage, and perhaps, to a certain extent, he himself was either the father or mother of it, because the Association was really started as a result of a letter which he wrote to THE FOUNDRY TRADE JOURNAL. One of the main benefits which had already been derived from the work of the Association was that the members of the trade had learned to respect one another very much more than they ever did before. They had learned that their competitors were very good fellows, and they had learned the proper lesson of friendship and hospitality. Having done so, they were in a position that evening to welcome their visitors in a most cordial and sincere manner, and they did so.

What the Foundry Industry Expects from its Supplier.

MR. A. W. G. BAGSHAWE, responding, said the Association was formed for the purpose of the trade, and not for scientific purposes. It was formed—or should be—entirely for the purpose of making money. There were other advantages. It was good for the trade, but primarily it was for the purpose of making working conditions and profit-making conditions better. Speaking as a foundryman—and he was proud to be one, because it was a man's job, and there were some things which the foundryman wanted to know from the suppliers of equipment. They came along and said they could sell the foundryman some product which was useful in a foundry, and the foundryman was told what it would do. What was wanted, however, was more definite data and better facts. In this, of course, he was not speaking personally as far as anybody present was concerned, but quite generally. The foundryman was offered firebrick or refractories of some kind, but he had never yet seen any information of how many tons of metal a certain type of cupola brick will stand under normal conditions before renewal. Again, salesmen did not come round with such information as how many pounds of metal can be removed with a pound of emery wheel. In a similar manner, people stated how many moulds can be made in an hour with a moulding machine, but they always forgot to say how many labourers had to be kept to feed the machines. These were things which the Association ought seriously to consider—viz., the possibility of giving those using foundry equipment the true facts of the case. It was up to the Association to do it if they were to live up to their reputation. Foundry organisation in this country was as bad as it could be. The Institute of British Foundrymen was doing what it could, but a great deal more required to be done, and the Association had great possibilities in this direction. He was speaking without authority, but he did not believe anybody in the foundry industry cared what they paid for their materials so long as they were all charged the same price. If the trade cared to form a price association, let it be done, but they must treat all users alike as regards the price charged for the products. In conclusion, Mr. Bagshawe said he had been committing the unforgiveable sin of talking shop, but, in apologising for that, he expressed the sincere thanks of the visitors for being invited to this first dinner of the Association, and at the same time expressed pleasure at the formation of it, because users knew the makers could do more for them than perhaps even the makers themselves realised.

An entertaining musical programme was provided during the evening.

Company Reports.

Shotts Iron Company, Limited.—Brought forward, £23,833; trading profit, £55,908; together, £79,741; depreciation, £32,000; interim dividend on preference shares, £2,313; interim dividend on second preference shares, £2,855; final dividend on preference shares, 2½ per cent., less tax, making 5 per cent. for year, £2,313; final dividend on second preference, 2½ per cent., less tax, making 5 per cent. for year, £2,863; ordinary dividend for year, 5 per cent., less tax, £16,000; balance carried forward, £21,396.

John Williams & Sons (Cardiff), Limited.—Profit, £10,791; brought forward, £4,139; total, £14,931; half-year's dividend on preference shares, 5 per cent. per annum (free of tax), £750; 2 per cent. interim dividend on ordinary shares (free of tax), £1,500; available balance, £12,681; half-year's dividend on preference shares to September 30, 1926, 5 per cent. per annum (free of tax), £750; final dividend on ordinary shares, 8 per cent. (free of tax), making 10 per cent. for year, £6,000; carry forward, £5,931.

Applying Science in the Foundry.

By C. H. Ridsdale, F.I.C., F.C.S.

(*Continued from page 476.*)

Cast Iron.

Though by present methods of manufacture cast iron is the product obtained before soft steel or wrought iron, it is a more complex body, and there are more points to watch to obtain good results. The modern scientific study of metals began with that of steel, and comprehension of the metallurgy and control of cast iron has largely grown out of it, so properly to understand the structure of cast iron one can best consider it in the reverse order to that of manufacture, and begin either with steel practically free from carbon, or with wrought iron, and trace it forward, for cast iron substantially follows the same laws as steel except in so far as modified by the differences in chemical composition.

Table I gives a general idea of the constitution of iron and steel viewed from various angles.

Ordinary carbon steel consists of iron with as low impurities, sulphur and phosphorus, as can be obtained by the particular process, a small quantity of silicon, an appreciable amount of manganese, and carbon from a trace to 1.5 per cent., the total elements other than iron not usually exceeding 1.5 per cent. *Normal grey foundry* cast iron contains 8 or 9 per cent. of elements other than iron, though modern special castings may contain only 4 to 6 per cent.

In the series of analyses—wrought iron, steels, and metals, both pig and casting—it will be noted first with regard to the *ultimate composition* which is what is usually reported, and regarded as "the analysis," this shows merely the quantities by weight of the respective elements determined, with iron by difference. It does not show whether they are free or combined, or, if combined, how they are.

The *wrought iron*, neglecting its slag content, contains the most iron, and is chemically similar to a very soft steel, except that there is hardly any manganese. An ordinary analysis does not make it clear that it contains intermixed with it, but not chemically combined, a small quantity of slag, viz., tap cinder, which, as the iron has never been melted during manufacture, has not been squeezed out of it. Part of the silicon, sulphur, phosphorus, manganese, and a little of the iron actually exist as slag, and part is alloyed with the iron. Also, the iron shown, having been as is usual taken by difference, includes a further part of the slag, in this case 1.1 per cent.

The *steels* are arranged in ascending order of the carbon, which, as impurities and manganese are all within the usual limits, is the dominant factor. It is all in the combined state.

The *metals* also contain combined carbon, which varies in quantity according to whether the sample is grey or white. The first four are also arranged in ascending order of the combined carbon, the grey hematite containing an amount between that of the medium mild and medium hard steel, the special cylinder casting the same as the medium tool steel, or more than sufficient for the whole of the iron to exist in the structural form known as pearlite which we will describe presently.

The next two metals each contain combined carbon quite outside the steel range, it being about twice as high as in the usual hardest steel. The last four metals are arranged in the ascending order of the phosphorus, the first being a little higher than steel or hematite pig, and the others quite outside the steel range. All the metals, except the white, contain also graphite, which, whilst it remains as such, is merely intermixed, as is the slag in wrought iron, and not chemically combined with the metal.

It will be realised, therefore, that apart from the mechanically mixed inclusions—slag in wrought iron, and graphite in grey metals—there is a considerable similarity between the whole series of wrought iron, steels, and metals, and as already stated, they substantially follow the same laws, and yield the same effects, the differences in behaviour being due to the differences of quantity rather than of element.

So the present-day high quality tests obtained from cast iron are due to the production in it of the constituents which give good results in steel.

Proximate Composition.

Table I also shows the usually accepted primary chemical combination of the elements by weight.

Manganese Sulphide.—Generally there is sufficient manganese present to combine with all the sulphur as MnS. If there is not, then the excess sulphur combines with iron, yielding a more objectionable compound.

Manganese and Iron Carbides.—The carbon not present as graphite is found combined with the portions of Mn not appropriated by sulphur, and with the iron to form Mn_3C and Fe_3C respectively.

Phosphide and Silicide.—The phosphorus and silicon are each shown combined with iron to form respectively Fe_3P and FeSi. Combination of some of these elements in other proportions are known but these are sufficient for the present purpose.

Free Iron is the surplus iron not chemically combined, and this amounts to 99 per cent. in the very soft steel, in the metals the highest is in the grey hematite pig, viz., 84 per cent. and the lowest, owing to its combination with carbon, is in the white hematite, under 48 per cent., whilst the grey phosphoric (Cleveland) pig contains only 74 per cent. These bodies are not homogeneously distributed throughout the mass of solidified iron, steel, or metal, and as it is according to the way in which they are combined and arranged in the structure of the mass which principally gives these materials their properties, it is desirable to know the *structural constitution*.

Structural Composition.

Graphite being merely intermixed throughout the mass, and having no appreciable strength, like slag, weakens it by reducing its area of continuity, just as the perforations round a postage stamp weakens the paper and enables it to be torn off readily. Obviously, besides the percentage by weight it is essential to know the percentage by *volume* of any constituent. In the sample of grey hematite pig the graphite occupies nearly 11 per cent of the total volume, and in the No. 3 Cleveland pig, nearly 10 per cent., so that if the sound mass, apart from graphite, had a tensile strength of, say, 20 tons per sq. in., this would at the least be reduced to 18 tons or less, even if the graphite existed in the most compact form, say, little cubes or square threads. But in metals of open grey fracture we know it exists in large thin flakes, which break the area of continuity by three or four times this amount, and correspondingly reduces the strength, so that often this is only from 8 to 11 tons or only 40 to 50 per cent. of what sound metal would have been had there been no graphite, or other inclusions.

The transverse test is similarly affected. Hence merely reducing the amount of graphite, more particularly by reducing the total carbon, in this, for one way, increases the strength of a casting, whilst changing it to the smaller and better distributed emulsified form, does this still further. The cylinder castings have appreciably lower graphite and total carbon than the pigs, and they both run about 14 to 15 tons per sq. in., which is considerably stronger than an ordinary grey casting.

Manganese Sulphide.—This, in the form in which it occurs, viz., mixed with other bodies, being fairly fluid at and below ordinary casting temperatures, and very much lighter than the molten metal, tends to rise and float on the top with any scum. Mixer scum has been encountered with over 40 per cent. manganese sulphide. Some scum is raked off, but when pouring from the lip of a ladle some will be carried down with the stream of metal into the mould, though, as long as the metal remains fluid, the sulphide tends to rise.

Hence in such castings as ingot moulds, sulphur is always much higher at the top than at the bottom, or even a little lower down. Even in pig-iron one may find three times as much at the upper corners as at the lower rounded part.

In casting from the bottom of a ladle (as with steel) much of this carrying down is avoided, the sulphide rising out all the time, and being thrown away when the slag left in the ladle is poured out. Such sulphide as remains in the casting is, with the phosphide, one of the last parts to solidify, and is therefore sometimes found as a coating inside blowholes or contraction cavities. Fortunately it does not form a large percentage of the total volume, so has correspondingly small mechanical effect.

Table I.—The Constitution of Iron, Steels and Metals.

ULTIMATE COMPOSITION BY WEIGHT PER CENT.

	Wrought Iron.	Steels.					Metals.							
		Very Soft.	Ordy. Soft.	Medium		Hard.	Medium Tool.	Hard Tool.	Pig Grey Hem.	Casting Spec. Cyl.	Pig M.tld. Hem.	Pig Ref'd White	Castings Special Cylinder.	Pig Mangf. Phos.	Pig No. 3 C'tvd.
				Mild.	Hard.										
CARBON	none	none	none	none	none	one	none	none	3.27	2.3–	0.5–	none	2.3–	2.4–	2.5–	3.0–
Graphitic	**0.05**	**0.03**	**0.10**	**0.26**	**0.46**	**0.72**	**0.90**	**1.20**	**0.39**	**0.90**	**3.0**–	**3.35**	**0.9**–	**0.75**	**0.8**–	**0.4**–
Combined	0.05	0.03	0.10	0.26	0.46	0.72	0.90	1.20	3.66	3.2–	3.5–	3.35	3.2–	3.15	3.3	3.4
Total ..	0.05	—	—	0.05	0.13	0.08	0.05	0.17	2.2–	1.6–	0.7–	0.5–	1.6–	1.8–	1.31	2.6–
SILICON ..	0.05	0.03	0.03	0.02	0.04	0.05	0.04	0.04	0.03	0.1–	0.15	0.07	0.1–	0.08	0.03	0.08
SULPHUR ..	0.10	0.04	0.03	0.02	0.03	0.05	0.04	0.05	**0.03**	**0.1**–	**0.06**	**0.05**	**0.1**–	**0.5**–	**1.05**	**1.40**
PHOSPHORUS	0.05	0.30	0.5–	0.5–	0.66	0.7–	0.6–	0.47	0.6–	0.5–	0.3–	0.25	0.5–	0.7–	0.6–	0.6–
MANGANESE	**99.70**	**99.60**	**99.34**	**99.15**	**98.68**	**98.40**	**98.37**	**98.07**	**93.48**	**94.5**–	**95.29**	**95.78**	**94.5**–	**93.77**	**92.71**	**91.92**
IRON*																

PROXIMATE COMPOSITION BY WEIGHT PER CENT.

Graphitic C.	none	none	none	none	none	none	none	none	3.27	2.3–	0.5–	none	2.3–	2.4–	2.5–	3.00
Mn Sulphide	0.08	0.08	0.08	0.05	0.11	0.14	0.11	0.11	0.08	0.27	0.41	0.19	0.27	0.22	0.08	0.22
Mn Carbide	none	0.27	0.48	0.50	0.63	0.65	0.57	0.43	0.59	0.35	0.04	0.14	0.35	0.60	1.66	0.49
Fe Carbide	**0.75**	**0.15**	**1.04**	**3.37**	**6.28**	**10.10**	**12.86**	**17.50**	**5.24**	**13.17**	**44.73**	**49.97**	13.17	10.62	10.32	5.49
Fe Phosphide	0.64	0.26	0.19	0.13	0.19	0.32	0.26	0.32	0.19	0.64	0.38	**0.32**	**0.64**	**3.20**	**6.72**	**8.96**
Fe Silicide	0.15	none	none	0.15	0.39	0.24	0.15	0.51	6.60	4.80	2.10	1.50	4.80	5.40	3.93	7.80
Fe (Free)*	**98.38**	**99.24**	**98.21**	**95.80**	**92.40**	**88.55**	**86.05**	**81.13**	**84.03**	**78.47**	**51.84**	**47.88**	**78.47**	**77.56**	**74.79**	**74.00**

STRUCTURAL CONSTITUTION BY WEIGHT PER CENT.

Graphitic C.	none	none	none	none	none	none	none	none	3.27	2.3–	0.5–	none	2.3–	2.4–	2.5–	3.00
Mn Sulphide	0.08	0.08	0.08	0.05	0.11	0.14	0.11	0.11	0.08	0.27	0.41	0.19	0.27	0.22	0.08	0.22
Mn-Fe Pearlite	none	2.04	3.68	3.84	4.82	4.99	4.33	3.27	4.50	2.70	0.33	1.06	2.70	4.58	12.68	3.76
Fe Pearlite	**5.63**	**1.13**	**7.88**	**25.37**	**47.28**	**76.02**	**94.72**	**90.07**	**39.44**	**87.34**	**59.19**	**53.96**	**87.34**	**80.00**	**69.19**	**41.69**
Free Fe Carb.	none	none	none	none	none	none	0.29	**5.54**	**none**	**1.59**	**36.87**	**42.79**	**1.59**	**none**	**1.12**	**none**
90% Fe, 10% P Eutectic	1.00	0.40	0.30	0.20	0.30	0.50	0.40	**0.50**	0.30	1.00	0.60	0.50	1.00	5.00	10.50	14.00
Fe Silicide	0.15	none	none	0.15	0.39	0.24	0.15	0.51	6.60	4.80	2.10	1.50	4.80	5.40	3.93	7.80
Fe (Free)*	93.14	96.35	88.06	70.39	47.10	18.11	none	none	45.81	none	none	none	none	2.40	none	19.53

It may be regarded as really nothing more than a slag or an inclusion such as graphite, and therefore its effect for a given quantity aiso depends on how it is distributed in the mass. Unfortunately it tends to form in elongated "lakes" along the grain junctions, so the more it can be induced to form in rounded masses or emulsified, the less harmful it is.

Pearlite is a structural constituent consisting of alternate layers of hard carbide of manganese or iron, with soft ferrite, or approximately pure iron, the carbide being the thinner, and the iron the thicker layer. It is therefore aimed at in castings where toughness together with a certain amount of hardness is desired. Although not a definite chemical compound, it does in practice work out to

$Fe_3C + Fe_{21}$, or 24 atoms of iron with 1 of carbon. Thus pure (100 per cent.) pearlite only contains about 0.89 per cent. carbon. It will be seen that in the medium tool steel with 0.90 per cent. carbon as part of the 98.3 per cent. iron is appropriated by phosphorus and silicon, there is not enough iron to absorb all the carbon as pearlite, so some has to exist as free carbide. With higher carbon there is still more free carbide.

In metal, owing to the lower total iron and the larger quantity appropriated by other bodies, usually the carbon existing as pearlite is not over 0.81 per cent. In the white refined hematite only 0.49 per cent. can exist in this form, and in mottled hematite 0.53 per cent., though in manganiferous phosphoric it runs 0.802 per cent., and in special cylinder casting 0.80 per cent.

Free Carbide or cementite is the surplus left over beyond that for which there has been sufficient iron to form pearlite, and is chiefly found round the grain boundaries of the harder steels and cast irons. Its hardness checks wear, and too much of it reduces the easy machineability of the metal.

Hence the refined white pig, though apart from the high combined carbon it is like a silicious steel, cannot be drilled or otherwise machined.

Phosphorus Iron Eutectic.

This contains 90 per cent. of iron and 10 per cent. phosphorus, whereas iron phosphide, Fe_3P, contains only about 84.5 per cent. iron with 15.5

Table I.—The Constitution of Iron, Steels and Metals—*continued.*

PROXIMATE COMPOSITION BY VOLUME PER CENT.

	Wro'ght Iron.	Steels.							Metals.							
		Very Soft.	Ordy. Soft.	Medium		Hard.	Medium Tool.	Hard Tool.	Pig Grey Hem.	Casting Spec. Cyl.	Pig M-tld. Hem.	Pig Ref'd White.	Castings Special Cylinder.		Pig Mangf. Phos.	Pig No. 3 Cl'vd.
				Mild.	Hard.											
Graphitic C.	none	none	none	none	none	none	none	none	10.56	7.58	1.70	none	7.58	7.86	8.17	9.62
Mn Sulphide	0.18	0.18	0.18	0.12	0.24	0.30	0.24	0.24	0.17	0.55	0.86	0.40	0.55	0.44	0.17	0.44
{ Mn Carbide	none	0.28	0.50	0.52	0.65	0.67	0.59	0.44	0.55	0.33	0.04	0.14	0.33	0.56	1.57	0.45 }
{ Fe Carbide	**0.80**	**0.16**	**1.11**	**3.56**	**6.62**	**10.61**	**13.52**	**18.32**	**5.02**	**12.89**	**45.20**	**51.15**	**12.89**	**10.35**	**10.05**	**5.26** }
Fe Phosphide	0.72	0.29	0.22	0.14	0.22	0.36	0.29	0.36	0.20	0.66	0.41	**0.35**	**0.66**	**3.32**	**6.92**	**9.03**
{ Fe Silicide	0.19	none	none	0.19	0.50	0.31	0.19	0.65	7.60	5.65	2.54	1.84	5.65	6.32	4.60	8.96 }
{ Fe (Free)*	98.11	99.09	97.99	95.43	91.77	87.75	85.07	79.99	75.90	72.34	49.25	46.12	72.34	71.15	68.12	66.24 }
Volume‡	101.37	100.15	100.22	100.34	100.68	100.91	101.02	101.40	110.70	108.47	105.19	103.78	108.47	108.98	109.15	111.62
Specific Gr...	7.75	7.85	7.84	7.83	7.81	7.79	7.78	7.75	7.10	7.25	7.47	7.57	7.25	7.21	7.20	7.05

STRUCTURAL CONSTITUTION BY VOLUME PER CENT.

	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
Graphitic C.	none	none	none	none	none	none	none	none	10.56	7.58	1.70	none	7.58	7.86	8.17	9.62
Mn Sulphide	0.18	0.18	0.18	0.12	0.24	0.30	0.24	0.24	0.17	0.55	0.86	0.40	0.55	0.44	0.17	0.44
{ Mn-Fe Pearlite ..	none	2.05	3.69	3.85	4.82	4.96	4.30	3.26	4.08	2.50	0.32	1.02	2.50	4.23	11.68	3.40 }
{ Fe Pearlite	**5.60**	**1.14**	**7.93**	**25.48**	**47.33**	**75.97**	**94.53**	**89.53**	**35.92**	**81.16**	**56.76**	**52.41**	**81.16**	**74.00**	**63.90**	**37.60** }
Free Fe Carb.	none	none	none	none	none	none	**0.31**	**5.80**	**none**	**1.56**	**37.20**	**43.81**	**1.56**	**none**	**1.05**	**none**
90% Fe, 10% P. Eutectic	1.07	0.43	0.33	0.22	0.33	0.54	0.43	0.53	0.29	1.00	0.62	0.52	1.00	4.95	10.39	13.60
{ Fe Silicide	0.19	none	none	0.19	0.50	0.31	0.19	0.64	7.60	5.65	2.54	1.84	5.65	6.32	4.60	8.96 }
{ Fe (Free)*	**92.96**	**96.20**	**87.87**	**70.14**	**46.78**	**17.92**	**none**	**none**	**41.38**	**none**	**none**	**none**	**none**	**2.20**	**none**	**26.38** }

* By difference and includes such small quantities of arsenic, copper, nitrogen, oxygen, nickel, or other bodies as may be present. Also in the case of wrought iron besides part of the impurities being present as slag a further 1.1 per cent. of slag is allowed for in the "Iron by difference," and accounts for the volume where shown being greater than unity instead of as in the steels.

† Slide (the analysis given here for mottled does not apply necessarily to the photomicrograph, which is from a different sample).

‡ Volume relatively to Ferrite taken as unity.

per cent. P. It consists therefore of Fe_2P dissolved in extra iron, equivalent almost to two extra atoms. It also is hard, giving resistance to wear (hence in sections, microphotographs, like carbide, it may be seen standing above the mass) but reducing toughness. It gives a more brittle

Iron Silicide and Silico-Ferrite.

The silicide is actually dissolved in the remaining iron to form silico-ferrite, which is not a definite chemical compound, and under the microscope all shows as ferrite. It is only shown

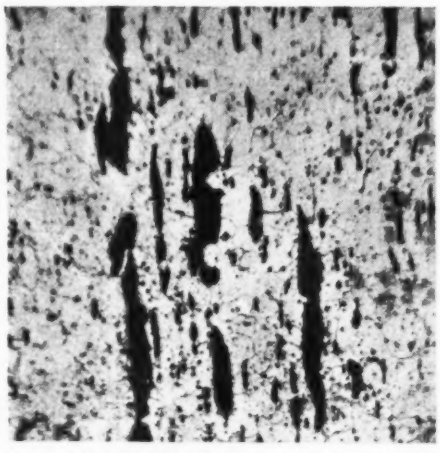


FIG. 1.—Wrought Iron C. 0.05% X 50. Etched rather deeply ferrite and slag streaks.

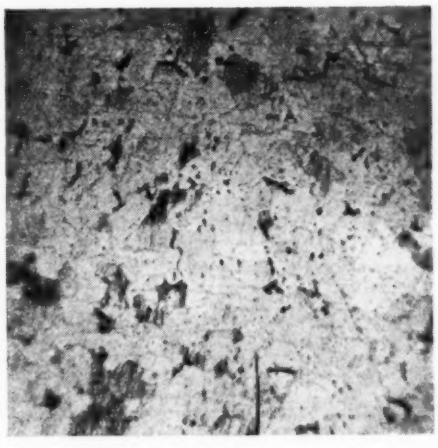


FIG. 2.—Steel C. 0.03% X 50. Etched rather deeply ferrite, slag and pearlite (black).

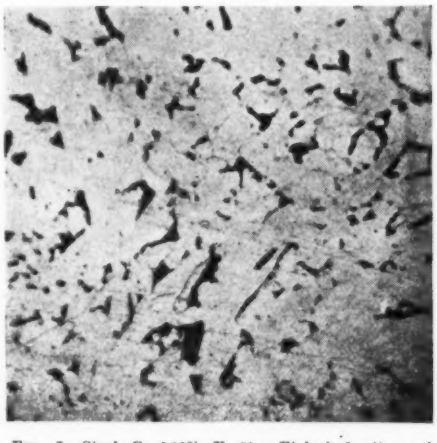


FIG. 3.—Steel C. 0.10% X 50. Etched ferrite and pearlite (black).

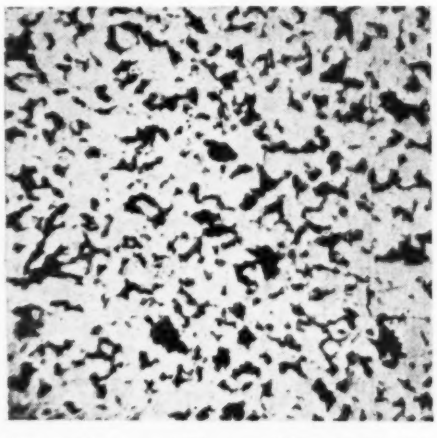


FIG. 4.—Steel C. 0.26% 50. Etched ferrite and pearlite.

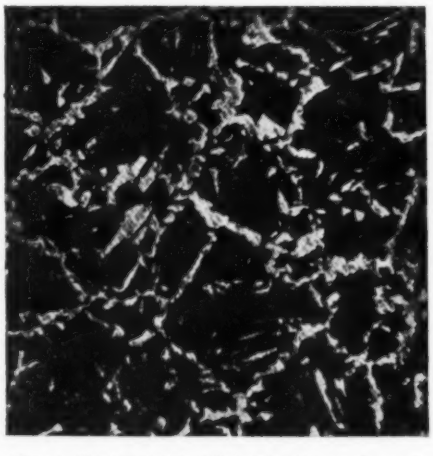


FIG. 5.—Steel C. 0.46%. Etched ferrite round pearlite (black).

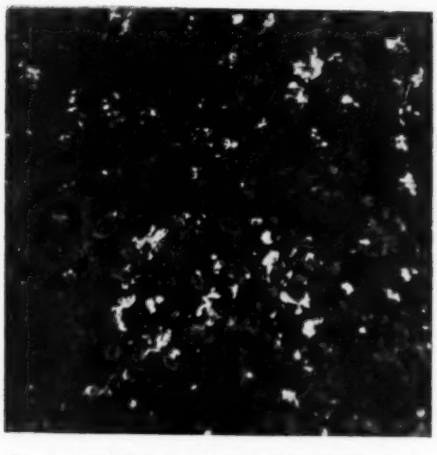


FIG. 6.—Steel C. 0.72% X 50. Etched specks ferrite, chiefly pearlite.

form of hardness in unchilled specimens than carbon does. As it remains fluid till a relatively low temperature, 980 deg. C., it tends to give a free flowing metal, but in thick castings there is liable to be a good deal of segregation, and in certain circumstances there is increased risk of tearing by contraction.

separately to indicate how rich in silicon this body is in the respective materials.

The silicide increases the fluidity and sound pouring of metal and improves its machining properties. It somewhat increases its hardness, but not much as compared with carbide or phosphide. This can be seen from the facts that

Sandberg steel—which has been in use for many years to give a better wearing tough tram-rail—contains from 0.3 to 0.5 per cent. of silicon, whilst a 4 per cent. silicon steel can be rolled into sheets and stamped, and recently a German steel known as "Freund" or "F," containing 0.15 per cent. C. and 1 per cent. Si, has been put forward. This combination, according to Dr. H. W. Gillett, gives a high yield point and high ductility. The foregoing may be chemically regarded as the primary structural constituents, though in practice they are to varying extents inter-dissolved as the silicide is in the free iron. Thus a phosphide eutectic containing carbon is met with.

There are also "transition" constituents, which have been arrested before they could form one or other of the primary constituents, whose occurrence depends on the rapidity of the solidification, and of cooling when solidified. It is out of the question in a paper of this character to describe the constituents Hardenite, Austenite, Martensite, Troosite, Sorbite, Osmondite, Steadite, Ledeburite, etc. The system of naming them is to be deprecated as, with the exception of the first, it conveys no idea either as to their appear-

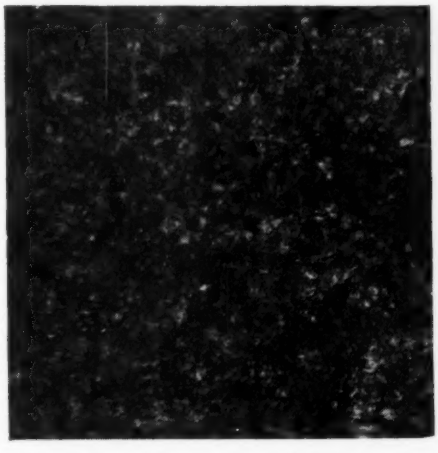


FIG. 7.—Steel 0.09% X 50. Etched all pearlite (eutectoid steel).

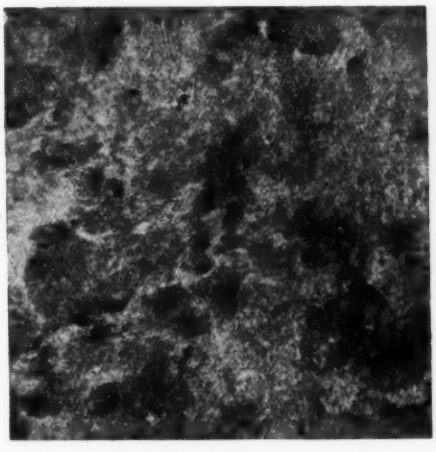


FIG. 8.—Steel C. 0.90% X 300. Etched showing band form of pearlite.

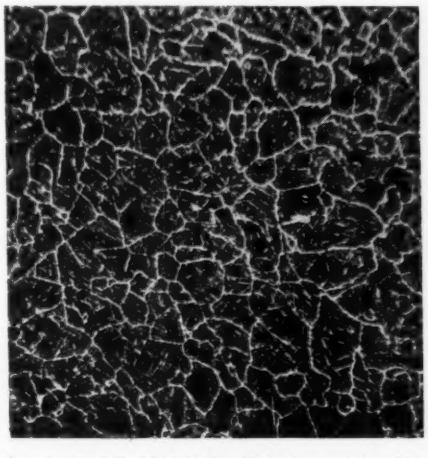


FIG. 9.—Steel C. 1.20% X 50. Etched cementite white round pearlite.

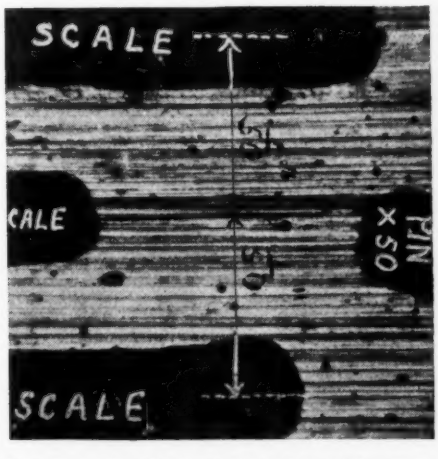


FIG. 10.—Scale and pin point (ink) impression X 50. Half min. divisions.

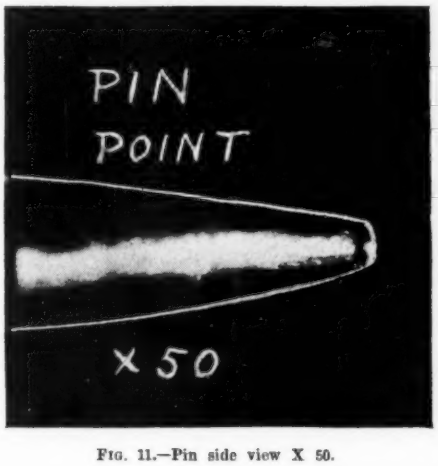


FIG. 11.—Pin side view X 50.

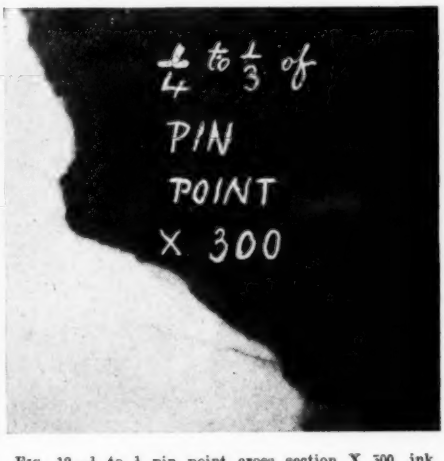


FIG. 12.—¼ to ⅓ pin point cross section X 300, ink impression on white card.

ance under the microscope or as to their effect on the properties of the steel or metal, although these depend mainly on the proportion of them and the primary constituents, whilst this depends on the composition, and thermal treatment, viz., casting temperature, rate of cooling, etc.

Thus foundrymen have to get the property they require by play upon these. The metal being *cast*, only such effects can be obtained as thermal treatment will yield, there is no work effect, as in steel or wrought iron.

In Table I, it will be noted that the *specific gravities* vary from 7.85 for the very soft steel down to 7.75 for the hard tool, the particular wrought iron shown, owing to the contained slag, being about the same, though if slag-free it would have been as high as the very soft steel, whilst the metals run from 7.57 in the refined white pig down to 7.05 in the No. 3 Cleveland.

Their *volumes relatively* to ferrite as 100, run from 100.15 for very soft steel, increasing as the percentage by weight of iron diminishes, to 111.62 per cent. for Cleveland pig.

The constituents of which they are composed run, acording to different authorities, as set out in Table II.

TABLE II.—*Specific Gravity and Relative Volume of Iron and Steel Constituents.*

Specific gravity and *volume* relatively to *ferrite* at 7.86, which being the densest is taken as unity by volume.

	Sp. Gr.	Vol. relatively to Ferrite.
Graphite	From 2.2 to 2.35	3.573 to 3.345
Manganese Sulphide	,, 3.55 to 4.00	2.214
Manganese carbide	About 7.61	1.033
Iron carbide ..	7.4 to 7.82	1.062
Iron phosphide ..	6.74	1.166
Iron 90%, P. 10% eutectic ..	7.14—7.16	1.099
Manganese pearlite	7.83	1.004
Iron pearlite ..	7.82—7.85	1.0051
Iron silicide ..	6.17	1.274
Iron (free) pure ferrite	7.86	1.00

These figures have been obtained from various sources and the author would specially acknowledge help given by Mr. J. E. Fletcher, Dr. W. H. Hatfield and Dr. Cecil H. Desch, each of whom has kindly supplied figures of their own compilation and indicated which they considered to be the most reliable.

It will be seen that the volumes of the other bodies relatively to ferrite the principal and densest constituent vary from only slightly greater, in the case of pearlite, to 2¼ times as great in the case of manganese sulphide, and 3½ times as great in the case of graphite.

Temperatures.

Whilst molten soft steel as run into the ladle may be from 1,550 deg. to 1,600 deg. C., and cast iron 1,300 to 1,350 deg. C., the setting or freezing points, vary from about 1,500 deg. C. for pure iron, to as low as 980 deg. C. for phosphide eutectic, a range of over 500 deg. Thus, apart from the immediate setting of the first portions of metal which come into contact with the relatively cold mould, there is a constant tendency for the purest and densest portions to solidify and settle out first, and the more impure less dense portions to remain liquid longest.

It is this which accounts for segregation (the local concentration of impurities), for the rotten condition of both steel and metal whilst only partially set, and, in certain conditions, for draws and liquid contraction cavities. Then, even after the last portions have set, not only do the the chemical constituents take different structural forms, but their coarseness or fineness varies according to the rate of cooling, whilst the grain size also is materially affected by it. Then again there is the effect of the gases given off by metal whilst passing from the fluid to the solid state, in relation to the production of sound blowhole-free castings.

Need for a Foundry Chemist.

The question arises, "Why should a chemist be needed in foundry work"? One reason is because foundry work is, or should be a laboratory operation on a large scale. One may retort, however, "Oh yes, it's all very well doing it in a laboratory, but in a works conditions are so different." That is true, but to make progress foundrymen have to find ways to control these conditions, and the nearer they get to making it into a laboratory operation the better success they will have. This is already being done with many types of manufacture, for instance—just to name two—explosives and dyes. Again, a chemist is by nature and training systematic, he understands the necessity of, and is used to working under, exact conditions of time, temperature, quantities, pressures, and so on, and has a clear perception and appreciation of the many values such as heat units.

It is therefore obvious that the proper control of all that effects the properties of a casting must be exercised by someone who understands them, and what conditions are necessary for their production at will. The author remembers reading the discussion on a paper in which the lecturer had been showing photo-micrographs of some good castings and saying those were what they needed, and one of the speakers said that was very interesting, but he wished Mr. —— would tell them exactly what to *do* to get those constituents into the castings. That appeal is excellent, because how to do it is, after all, the real question.

Anyone who has lived in a works for a number of years realises that successfully to achieve the result there must be knowledge—not assumption—that all the details are carried out correctly. Everything must be systematised tactfully, for unless managers, foremen, and men work together all may be upset.

It is essential for exact working and high-class products that the analyses of each consignment of pig, scrap, coke, limestone, or other materials used, should be known, and also the moisture in the sand, its fineness, porosity and softening point.

The charging should yield uniform metal, even of the smallest portions drawn; the blast pressure and volume, tapping and casting temperatures, mould temperatures, and many other details, should be regularly observed, and official records of these, together with full chemical, mechanical and microscopic tests of the resulting products kept.

(To be continued.)

The Care of Files.

The file can scarcely be described as an ordinary patternmaker's tool, but it is essential that he should have several files to keep bits, saws, etc., in condition. For metal patterns, of course, files are the finishing tools. It is not surprising that so few patternmakers know much about files as they are not used like planes, chisels, or gouges. It is not generally known, for instance, that files may be sharpened by dipping them into sulphuric acid, but care must be taken not to permit the acid to come into contact with one's clothes or person. Water is used to wash off the acid.

Files should not be thrown into drawers and mixed with other tools, but should be set in racks or drawers made for the purpose. A mechanic would not throw away a straightedge into a drawer containing other tools, and a file should be given similar consideration, as every nick in the teeth impairs the efficiency of the tool.

Each file should be provided with an individual handle. This prevents injury to the hand of the worker and aids in the proper use of the file. Handles should be carefully fitted and be made of a size proportionate to the file. In removing a handle from a file, strike the handle at the end nearest the file, by sliding a piece of hard wood along the surface of the file, as the blow is struck with it. Do not use another file or metal object in thus removing a handle, as it will injure the latter.

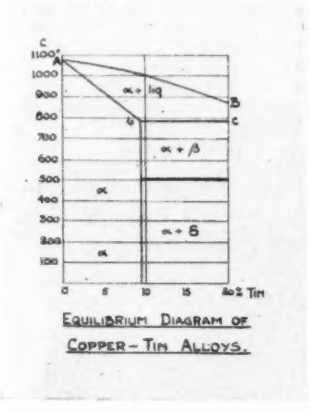
To test a file, hold it so that the light will be reflected sharply from the teeth and observe whether their edges are flattened and appear as white lines. If so the file is dull. J. E.

"Non-Ferrous Foundry Practice."*

By Arthur Logan.

The first outstanding fact about brassfounding as compared with ironfounding which must strike everyone is that of purely commercial considerations, *i.e.*, the big difference in the cost of the metal going into the respective moulds. Whereas a pound of good-quality cast iron costs only a matter of three farthings, non-ferrous alloys may range from 7d. to 1s. 6d. per lb., or from 9 to 24 times as much. Assuming the same percentage profit in each case, castings in non-ferrous alloys will yield a much higher profit compared with similar castings in iron. A brass foundry of the same output as an iron foundry will therefore have a far greater commercial value per annum. Conversely, whereas a waster in cast iron may not amount to much, a similar waster in non-ferrous means a far greater loss of potential profit.

The following remarks are mainly concerned with some of the metallurgical considerations of brass founding, consequently there is little to say regarding actual brass moulding as compared with iron moulding. One thing is certain, however:



EQUILIBRIUM DIAGRAM OF COPPER-TIN ALLOYS.

FIG. 1.—EQUILIBRIUM DIAGRAM OF THE COPPER-TIN ALLOYS, UP TO 20 PER CENT. TIN.

a good brass moulder can go over to iron and produce first-class iron castings, but an iron moulder cannot produce successful non-ferrous castings without some previous brass-foundry experience or knowledge. Generally speaking, brass moulding calls for greater care and accuracy at every stage. Although non-ferrous alloys melt, and are poured at a very much lower temperature than iron, it is surprising how fluid and searching some of these alloys are upon the mould.

Solidification of Non-Ferrous Alloys.

In tracing trouble, it is necessary to understand the principles which govern the solidification of the particular metal or alloy in question. As alloys of the bronze type are greatly used, the equilibrium diagram of the copper-tin series should be consulted. The complete diagram is rather complicated, but the portion containing up to 20 per cent. tin (which includes all the commercial bronzes) is quite simple, and worth studying by the practical foundryman. Pure copper has a freezing point of 1,084 deg. C., and pure tin a freezing point of 232 deg. C., consequently none of the bronzes can have a freezing point as great as 1,084 deg. C., as the greater the amount of tin added, the lower the freezing point of the resulting alloy.

The line A—B (see Fig. 1) is called the liquidus, as at temperatures above this line the alloys are completely liquid. The line A—B—C is called the solidus, and at temperatures below this the alloys are completely solid. Between the two solidification takes place during an interval of time. Any line shown below the solidus relates to changes which take place in the solid material whilst cooling. Such a change is shown to take place at 500 deg. C. in alloys containing over 9 per cent. tin. To take an actual example: In a bronze containing 10 per cent. tin the first solidification commences about 1,000 deg. C. As can be expected with two metals having such big differences in freezing points, it is relatively pure copper which starts to solidify first. This shoots out in straight lines forming a sort of skeleton or backbone for the remainder of the alloy to solidify round. Solidification commences simultaneously throughout the alloy at all points at which the temperature is 1,000 deg. C. In the case of a casting, the metal which travels the furthest, *i.e.*, which is cooled the most, is the first to solidify, and this solidification naturally always commences at the wall of the mould, and proceeds inwards. The dendrites, as they are called, which have started to grow, soon find their progress checked by others round them, consequently branches are thrown out at right angles to the main axes, and when these meet with interference, branches again shoot out at right angles. In this way the crystals are gradually built up, and it will be seen that the shapes of the crystal boundaries are entirely haphazard, and are due to the interference one with another. The size to which the crystals grow depends upon the rate of cooling, which in turn depends upon the casting temperature and the size and section of the mould, and in a lesser degree on the ramming and thickness of sand.

When a waster casting is broken up, examination of the fracture (when guided by practical

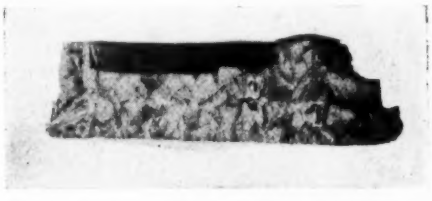


FIG. 2.—FRACTURE OF STRONG GUN-METAL. (BROKEN HOT.)

experience) will indicate whether the casting temperature was at fault. As the temperature falls, solidification proceeds and the liquid portion becomes richer in tin, as also does the material which is building up the structure, and which is known as the alpha solid-solution. At 790 deg. C. the alpha formed should contain 9 per cent. tin, and the remaining tin-rich liquid now solidifies. If a specimen of 10 per cent. bronze was quenched in water from just below 790 deg. C. it would be found to consist of two constituents. One the heterogeneous alpha from almost pure copper up to approximately 9 per cent. tin, and a small amount of what is called the beta constituent, which contains approximately from 22.5 to 27 per cent. tin. This beta constituent is not stable, and when slowly cooled to 500 deg. C. breaks down into alpha and a third constituent known as delta.

According to the equilibrium diagram, a 10 per cent. tin bronze should contain only very small amounts of the beta constituent (or, as it finally appears in the casting, the delta constituent), but in actual practice, however, the rate of cooling is the most important determining factor). The slower the rate of cooling, the greater the amount of beta formed, and consequently the greater the amount of delta found in the casting. This has a very practical application. The delta constituent is quite different in physical properties and appearance from the alpha matrix in which it occurs, and it influences the physical properties of the casting containing it in proportion to the amount present and its distribution. The lecturer then described a series of photo-micrographs shown on the screen illustrating the structures of sound, strong gunmetal, and weak, unsound gunmetal. The chief outstanding differences being in

* An extract of a Paper given before the Middlesbrough Branch of the Institute of British Foundrymen.

the case of the good gunmetal that the strong interlacing dendritic structure was strongly developed, and this was always associated with a very small amount of the delta constituent and freedom from oxide films, etc. In the case of the weak gunmetal, the pronounced dendritic structure was replaced by a weak, loose arrangement associated with a large quantity of the delta constituent in a more or less network formation, and often considerable oxide inclusions and films. The importance of the delta constituent was shown when its properties were described. The delta is a hard, brittle, bluish-white compound of copper and tin in the proportion of one atomic part of tin to four atomic parts of copper (actually approximately 32 per cent. of tin). Being in itself hard and comparatively brittle, it imparts

FIG. 3.—MACRO OF GUN-METAL.

these qualities to the casting in which it occurs, reducing the tensile and elongation in proportion to the amount present. Foundrymen cannot always look at the structure of their castings through a microscope, but the fracture of the material does to some extent give an idea of the type of structure which the material possesses. Fig. 2 illustrates the intercrystalline fracture of a piece of strong gunmetal when broken hot, whilst Fig. 3 shows the same piece of metal sectioned and etched to show the microstructure or crystal arrangement.

If a consignment of scrap gunmetal is being bought, and the fractures of the material resemble that shown, it can be fairly safely assumed that material of good quality is being obtained. On the other hand, if any pieces have fractures similar to that shown in Fig. 4 they should be

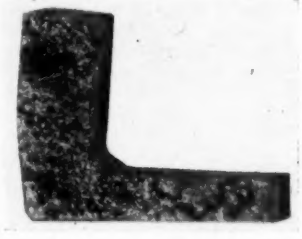


FIG. 4.—FRACTURE OF WEAK GUN-METAL. (BROKEN HOT.)

FIG. 5.—VIEW OF FOUNDRY WITH BATTERY OF PIT FIRES.

rejected. Similarly any risers or runners broken from castings giving fractures of this kind indicate that the structure of the material is at fault, and a poor result can be expected from the casting. If subject to hydraulic test, it will in all probability prove porous. The physical properties of gunmetal are thus dependent upon the structure, and the practical question then arises as how best control the material in order to produce the right type of structure.

Careful Melting Essential.

In many brass foundries the old-fashioned type of pit fired furnace is still in use, and although this type is far from ideal, yet it has a number of good points. Its first cost is low, and it is cheap to maintain. These advantages, however, are probably much more than counterbalanced by its low efficiency. It is also slow in melting, but except where mass production is in operation, this need not necessarily be a disadvantage. The slower melting probably leads to economy of crucibles, and these are an important item. Where care is taken, the crucible with natural-draught pit-fire melting is capable of giving the least oxidised material. Other forms of furnace used for brass melting are the tilting furnace, either coke or gas fired, or, as demonstrated at the recent Foundry Trades Exhibition in London, oil fired. Where larger quantities of metal are required at one time, reverberatory furnaces are used. Generally the pit-fire type only take up to 300 or 400-lb. crucibles, and a number of units are built together. Where more than, say, a ton or 30 cwts. of metal are required for one cast, then a reverbatory furnace must be used, and these can be built to suit whatever capacity is required. Fig. 5 is a general view of a foundry, and shows a battery of 12 pit fires and one tilting furnace.

Method of Making the Alloy.

The copper should be charged into the crucible, and, if scrap is being used, this should go along with it. A good covering of charcoal should be given, the fire made up, and the furnace cover put on. A good plan is to stand the crucible on a firebrick slab, then as the fire burns away the crucible remains undisturbed. The melting should be as rapid as possible. When the contents of the crucible are just molten, the zinc is added, then the tin, and the right amount of superheat is attained as rapidly as possible. The mould should always be completely ready before the metal, so that the moment the right temperature is reached the pot can be withdrawn from the fire, and, after careful skimming, poured. These precautions are all with the object of preventing oxidation of the copper. A very large proportion of the troubles which occur in non-ferrous castings is a direct result of this one thing—oxidised material. When it is realised how readily and easily copper

picks up oxygen when heated, and especially when molten, the importance of taking the utmost precautions against oxidation will be appreciated. A very simple object lesson, and one which should be brought to the notice of all furnacemen, is to take a sheet or piece of scrap copper and place it in the fire for a few minutes. If it is lifted out carefully and cooled down on a plate it will be found to be thickly covered with a black powdery scale. This is the copper-oxide which has been formed as a result of the combination of the metallic copper with oxygen from the air. At the temperature at which copper is molten this reaction takes place with great rapidity whenever the surface comes into contact with the air. If the copper-oxide so formed would come to the top of the metal it could be skimmed off, and the only trouble would be the loss of copper. Unfortunately, however, copper has the property of dissolving or alloying with its own oxide, and all the copper-oxide formed during melting goes into the alloy. If no steps were taken either to prevent the formation of oxide during melting, or to remove the small amount which is formed in spite of the greatest care, the resulting alloy would be sluggish and pasty, and castings poured from such metal would certainly be unsound.

In the case of Admiralty gunmetal, the composition is 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc, and the function of this small amount of zinc is to remove the oxide formed during melting. The correct time to add the zinc, therefore, is before the tin. If this is done, zinc unites with the oxygen from the copper-oxide, forming zinc-oxide, which is a light white powder, and is not soluble in the molten alloy. Zinc alone is not a perfect deoxidiser, for if the metal is badly oxidised it will not reduce more than a portion of the oxide present, and in any case, even with material which is carefully melted, it does not remove every trace of oxide. It is a good plan, therefore, where the highest quality material, giving the best possible results, is desired to add a further deoxidiser in the form of a phosphor-tin. Very little of this is required, the aim being just to add sufficient to deoxidise and leave practically none, or little more than a trace of phosphorus in the finished metal. The object is to get the metal as thoroughly deoxidised as possible before the addition of the tin, not only to prevent the loss of valuable tin by the formation of tin-oxide, but because tin-oxide once formed is very difficult to get rid of. Moreover, tin-oxide does not free itself so readily from the metal as does zinc-oxide, and it has a bad habit of crystallising in small crystals of tremendous hardness, which are detrimental to the material.

(To be continued.)

Foundry Statistics.

In October Belgium had 55 blast furnaces working, an increase of 13 over last December. This country made 8,060 tons of steel castings, as compared with 7,690 tons in September and a monthly average of 5,562 in 1925. In France on November 1 there were 154 furnaces in blast, which during October made 147,235 metric tons of foundry pig-iron. The output of steel castings was 13,201 metric tons.

For the first half of this year Italy has imported 6,490 tons of cast iron pipes and 5,756 metric tons of other castings, both iron and steel. Of pig-iron 114,291 tons were imported.

British India, during the first nine months of the current year, exported 235,101 tons of pig-iron (as against 302,996 in the corresponding period last year), of which 163,504 tons went to Japan, 49,504 tons to the United States, and the rest to other countries.

In October Germany made 11,400 as against 10,634 tons in September of steel castings from the basic process; 5,469, as against 5,588 tons of acid steel castings, and 937 tons, as against 775 tons of crucible and electric steel castings.

MR. THOS. HAGON, who has been secretary to Brown, Bayley's Steelworks, Limited, for the past eight years, has been elected a director of the company.

A New Roll-Surface Pyrometer.

In mills rolling hot steel billets considerable damage may result from starting up a set of rolls without pre-heating, and hitherto it has been rather difficult to ascertain the temperature by an ordinary thermometer. The new Cambridge Surface Pyrometer shown in the accompanying illustration should prove of considerable usefulness in this connection. It is a patented device for measuring the surface temperatures of heated rolls, and has been recently placed on the market by the Cambridge Instrument Company, Limited, 45, Grosvenor Place, London, S.W.1. The instrument is extremely simple to use, and is entirely self-contained. The overall dimensions are 9-in. × 4 in. × 3 in., and the weight about 18 oz. It is of the thermo-electric type, a millivoltmeter being calibrated to read directly in degrees of temperature.

In this pyrometer quickness of action and accuracy of reading are both secured by a simple modification of the thermo-sensitive element. The thermocouple in this instance is actually made in the form of a thin and comparatively wide strip of metal, and comprises two pieces of dissimilar

THE CAMBRIDGE SURFACE PYROMETER.

metals (copper and constantan) joined together end to end, and rolled out so as to form a continuous strip with the junction in the middle. When this strip is brought into contact with the hot surface, the area of contact is large in comparison with the thickness of the metal, and the thermocouple practically forms, as it were, a part of the actual hot surface, so that the temperature is taken up almost instantaneously. When using the instrument for measuring the temperature of a hot roll, the thermocouple strip is simply pressed into contact with the surface of the roller, and the deflection of the indicator pointer gives the temperature directly in degrees Fahrenheit (or Centigrade).

Personal.

MR. G. MURE RITCHIE has resigned his position as chairman of Palmers Shipbuilding and Iron Company, Limited, and will probably be succeeded by Lord Aberconway, acting chairman of the company. Two new directors have been elected:—Mr. C. F. Spencer, 123, Queen Victoria Street, London, E.C., and Mr. J. M. McFarlane, who has been for several years the shipyard manager.

PROFESSOR DR. G. HERTZ, to whom has been awarded the Nobel prize for physics of 1925, together with Prof. Dr. J. Franck, was born in 1887 in Hamburg. Professor Hertz is a nephew of the famous scientist of the same name, who by discovering the propagation of the so-called Hertzian waves has laid the foundation of modern wireless communication. The following years he started collaboration with Prof. Franck at the Berlin University, which resulted in a good deal of experimental research about the conduction of electricity through gases, leading to very important results. This explains why the Nobel prize has been awarded to both scientists. In 1913 the world of physical science had been startled by a theory of the atom published by the Danish physicist, Niels Bohr. Franck and Hertz, however, have been the first to show by experiment that the collision between the electron and an atom could produce a radiation of a certain predetermined wavelength. In 1921 Dr. Hertz entered the Physical Laboratory of the Philips' Lamp Works, as a research physicist, where he continued his experiments. Exactly a year ago Dr. Hertz accepted the chair of physics at the University of Halle (Germany), also taking charge of the physical laboratory as its director.

The International Foundrymen's Convention at Detroit.

The Tour of Overseas Foundrymen under the Auspices of the American Foundrymen's Association.

(*Continued from page* 490.)

BY OUR SPECIAL CORRESPONDENT.

Detroit.

Of Detroit there is much to tell, and, in truth, the half will never be told. First, hearty handshakes at the Hotel Statler, of which caravanserai nothing but good can be said, and then to refresh the inner man, practically breakfastless from the boat.

Led by the seasoned pioneer, Kent Smith (one *au fait* with the modes, and *áu courant* with the customs), through a door marked with the mystic word "Cafeteria," down winding steps to a marble hall, in Indian file past a pigeon hole, gathering up a tray, napkin, knife, fork, and spoon, and then *en queue* along a marble counter, where divinities presided over choice viands, smoking hot or ice cold, as best became them. Sliding our several trays along a couple of brass rails, we indicated in dumb show our preference for this or that dish. Veering undecidedly between the varying charms of "cold slaw," chopped chicken's liver, "cold borscht" with sour cream, and "baked weak fish," our plate of three divisions was soon filled with a satisfying meal. Passing before the presiding goddess, who with a nod summed up ourselves, our appetites, and our choices, and gravely handed us a ticket indicating the price we should have to pay for satisfying the former with the latter, we took our seats at marble tables, and helped ourselves in several senses of the word.

A Solemn Rite.

In an ordinary restaurant, by the way, the waiters, which are non-existent in a cafeteria, make the swift bringing of a glass of iced water to the arriving guest their first act. It is a solemn rite signifying at one and the same time the purity of the motives of the establishment, a welcome (if a cold one) to the guest, and an act of hospitality in that there is no charge for the water. In the "self-service" of a cafeteria one misses this graceful touch, but notices that if left to himself the American's choice of a beverage is not iced water at all, but in seven cases out of twelve, hot coffee!

We formed a high opinion of the cafeteria meal, chosen by sight instead of imagination, expeditiously supplied at low prices, and should welcome high-class establishments of this kind in our own large cities.

The inner man thus fortified, all roads led to the Convention. Early astir in that rosy morn, had been the devotees of ye Ancient Art of Casting. In the words of the poet,

> "When down the street
> The Dawn, on slipper'd feet,
> Crept like a frightened girl,"

it had overtaken American foundrymen, intent on exercise and on arrival at the Exhibition six miles away before it opened to the public at half-past eight a.m. Were they not agog, and eager as a warhorse that scents the battle from afar, to view the wonders of the world-announced Foundry Exhibition some of them had come 1,900 miles to see?

A Very Early Bird.

Affairs commence betimes in the States, for we found the American a very early bird, oft-times working in his office whilst we British were telephoning for the morning cup of tea, or still battling with the bacon.

A taxi cab was pressed into the service, and such a taxi! A beautiful six-cylinder Buick or Studebaker eats up the six miles in a stride, and is to all intents and purposes a private car, the driver of which is a courteous gentleman of unimpeachable integrity. Detroit differs from New York in that the former does not find it necessary for its taxis to bear within their interior a photograph of the driver, with details of his name, age, and career, and with instructions to the passenger immediately to call the police if he should find the driving seat occupied by any person other than he whose photograph is displayed!

However, in the car we sped through the crowded streets, past giant skyscrapers here and there, noting the multitude of motors, along a broad thoroughfare, tram-lined, and "jitneyed," past the General Motors building (said to be the largest office building in the whole world), past Henry Ford's Highland Park Works, and the place where Fisher bodies are made, and so to the "State Fair Grounds."

The State Fair Grounds.

These grounds are what we should describe as a park, consisting, as they do, of gravel paths, lawns, flower beds, trees and shrubs, and, in addition, a series of permanent buildings eminently suitable for housing an exhibition or providing the venue for a convention.

One huge chamber was built in the form of an oval amphitheatre, with ranges of seats, rising tier upon tier the one above the other, all round a flat central arena, in which were staged exhibits of the heavier type. Never was there such a jolting and ramming, banging and thudding, heard before. The floor was sanded deep as any foundry, and had a very familiar feel to the feet of a foundryman—a happy touch! It is but bare truth to say that here was indeed a fine show of labour-saving devices spread out for the benefit of a founder.

A Message from Overseas.

"Art is long, but life is short," says the philosopher, and such a galaxy was there that no more than a brief mention can be accorded to each of them; but first we met Mr. David McLain—the McLain of "Semi-steel" fame, and very, very glad was he to meet his British friends again. His conversation has lost none of its charm, and when we parted we pressed him for a message.

"Tell my dear friends in Great Britain," said he, "that I love them just as much to-day as I did the day I left, and that I am vitally interested in both their happiness and their success. Please convey this message to my foundry friends, and especially to those I made during my visit in 1922. In Great Britain I met gentlemen as fine as any I have ever met, and if I could spend half my life in Great Britain and half in the United States, I should be indeed a happy man."

Round the Stands.

Going the rounds of the stands, the first was the JERVIS B. WELL COMPANY, Detroit, who showed endless chain conveyors of the "cutest," vertical as well as horizontal, made of drop forgings throughout, and with the number of moving parts inexorably eliminated by careful thought.

The ROYER FOUNDRY & MACHINE COMPANY, Wilkes Barr, reminded us of the hilltop station where we stopped to cool off after climbing the Alleghany Mountains, on the way to Buffalo. So we had a good, long look, and were fascinated with a portable sand mixer and aerator on wheels, but driven by electricity. As fast as the sand was shovelled in, just so fast did it come out,

and in such a stream, with a tail like a comet, that there was no room for doubt about either mixing or aeration! It was confided to us that Pneulec were agents in Great Britain. The stand of the OSBORN MANUFACTURING COMPANY, of Cleveland, really came second in succession, but it was an easy first in impressiveness. Alive with urbane salesmen and smiling principals, it effectively occupied a space of the largest, with jolt squeezer moulding machines, sand-straddler squeezers, and a weirdly wonderful work-eating monster, adjectively described as the "Osborn Jolt Rollover Squeeze Pattern-draw Moulding Machine," but known in the works, we understood, as the "JRSPM"!

This and the others between them would do nearly anything but collect the account for the casting, and how a new foundry could call itself properly equipped without the aid of Osborn we know not.

Musing on this, we were brought back to every-day life with a "plain jolt" when we were invited to see a "Flask-filling Machine." Feeling expectantly at our hips, well aware of the nakedness of the land, and our own receptive abilities, we approached with interest, all ears for a fruity gurgle. But no! 'twas but a hopper fitted with a very artful electrically-operated conveyor-filler, which pushed into a flask (small "f," please!) up to 2 cubic yards of *sand* in a minute!

Hiding Our Disappointment.

Hiding our disappointment, but more than half fearing its repetition, we heard the word "treating." Alas! it was but a sand-treating mill—clever enough, admittedly, and actually dealing with up to 65 tons in an hour with the utmost ease and in a simple compactness we could not help admiring. But we could stand no more, and, pausing only to wring the hand of Mr. Atwater, whose name did not surprise us, and cast an admiring glance at the profile of Mr. F. G. Smith, the President, we passed on with a word to Mr. Wise, thanks to Mr. Oyster for opening up matters of such interest, and "goodbye" to Mr. Adam, the first man we saw on the stand, he mentioning—confidentially—that Jackmans were their British agents.

The INTERNATIONAL MOLDING MACHINE COMPANY, Chicago (note that they leave "U" out), next enchanted our attention. Here were moulding machines in variety, as we have seen them, gracing British, American, French, and Italian foundries. It must be confessed here that the principal exhibit on this stand were a couple of perfect blondes making perfect cores in a perfect core-making machine of a neat and useful type. "Gentlemen prefer blondes" murmured a Scottish colleague, and we could not deny the soft impeachment, and passed on to where duty called, and there was less competition—at the exhibit of the AMERICAN FOUNDRY EQUIPMENT COMPANY. Learning that the home of this firm was at Mishawaka, Indiana—harmonious and sonorous—we expected to find the principal, Mr. Minich, quite a romantic figure, but immediately recognised him as one of those who had so warmly welcomed us in New York, and were glad to renew the acquaintance. His show was both striking and effective. Imagine a huge vehicle like a steam cultivator, travelling along under its own motor power. Approaching a heap of old sand, it manœuvres itself into position, attacks the sand with a sort of "Now, let's have no nonsense about it" air, turns it over, throws it round, cuts it up, screens it, takes out all the rubbish, and leaves it on the floor a tidy heap of aerated sand, which it straddles like a conqueror, all in the twinkling of an eye. This wonderful sand-cutting and screening machine is the result of five years' work and experiment, and is a unique aid in a large foundry.

(To be continued.)

THE PARTNERSHIP heretofore subsisting between Messrs. J. Appleton and G. C. Howard, brassfounders and engineers, Salisbury Street, St. Helens, under the style of Appleton & Howard, has been dissolved. Mr. J. Appleton will continue the business under the same name.

Institute of British Foundrymen.

LONDON JUNIOR SECTION.

The first general meeting of the recently-formed Junior Section of the London Branch was held on Friday, November 26, in the offices of the Institute, 38, Victoria Street, Westminster, S.W.1.

There was a very gratifying attendance, over which Mr. F. P. Hull, the President of the Junior Section, presided.

After various business matters had been dealt with, Mr. Robert J. Shaw was asked to give his lecture on "Patternmaking from the Moulder's Point of View." Mr. Hull, briefly addressing the meeting, thanked those present for his election, and promised to do his best for the section. He said that they were indebted to Mr. Shaw for coming to talk to them that evening, and that all present were anxious to hear his lecture on patternmaking. He outlined the objects of the Junior Section, which had a very wide scope amongst the numerous foundries in London and the home counties, from which they hoped to draw quite a large membership. He requested the members to press the advantages of membership amongst their colleagues, particularly as they expected to have some interesting lectures from prominent foundrymen in the future.

Patternmaking from the Moulder's Point of View.

The lecturer, in his opening remarks, laid great stress on the fact that patterns are only tools to enable the moulder to produce castings, and their usefulness depended on their being so constructed that moulds could be made in the best way and with a minimum of labour; the same applied to the design and construction of core-boxes, and, finally, that when the moulds and cores came to be assembled, the work could be proceeded with in its proper sequence, so that venting and the supporting of cores could be done with certainty. In his (the lecturer's) opinion, this latter point was the test for good patternmaking, as it was no uncommon occurrence to find beautifully finished patterns where either the parting lines were wrong or the pattern was arranged to mould with the wrong side uppermost, or both, and possibly with cores that could not be placed in position easily. He pointed out that both patternmakers and moulders ought to be able to help each other in these matters more than they did at present. The weak point on the patternmakers' side was that so many of them had no foundry experience, and on the moulders' side that they could not usually read drawings sufficiently well to be able to visualise the moulding of the job, and so be in a position to advise the patternmaker. At present the moulder is, in most cases, only able to criticise the pattern after it is completed, which is not a very helpful proceeding. A large number of pattern examples of a general type of construction were discussed, and their poor design or construction contrasted with design and construction based on founders' requirements.

During the lecture Mr. Shaw illustrated his remarks freely on the blackboard in discussing both general principles and also particular examples, a number of the latter being on view, and ended by showing the not inconsiderable differences between core boxes arranged for ordinary sand and those for oil-sand. He explained the construction and good points of a number of excellent examples, some of which also showed the further differences between patterns for jobbing and those for repetition work.

The lecture gave rise to considerable discussion among the young men present, after which a hearty vote of thanks was accorded to Mr. Shaw.

Catalogue Received.

Refractory Cements.—The General Refractories Company, Limited, of Sheffield, have sent us an advance copy of an artistic little booklet containing 12 pages, which describes the properties of Pyrolite. This material is a refractory cement used for bonding together cupola bricks or furnace linings. It is said to be an improvement over magnesite cementite, and it is recommended by the manufacturers as a preservative when merely painted over brickwork, a phase of furnace construction not yet fully appreciated.

Lancashire Foundrymen Discuss Malleable Castings.

At the November meeting of the Lancashire Branch, held at the Manchester College of Technology, the Branch-President, Mr. S. G. Smith, in the chair, a Paper was read by MR. A. E. PEACE, of Derby, upon the "Manufacture and Properties of Blackheart Malleable Cast Iron." The ground covered was similar to that given by the author before the East Midlands Branch which we recently published.

MR. J. S. G. PRIMROSE said to those among them who had the privilege a short time ago of visiting the works where Mr. Peace was engaged, it brought home what they then saw in a practical way and supplemented the information they then gained. When it was published it would be a standard to which they could refer. In the first place he should say that here they had an example of the careful and thorough control which was necessary in carrying out what was apparently a very simple operation. They had an iron with what might be called a perfectly white fracture made into an iron with what might be called a perfectly black fracture, by simply annealing and precipitating the carbon. It seemed exceedingly simple, but the composition and temperature must be controlled, and that was something to which the ordinary ironfounder was not accustomed. Would metal of the same composition be suitable for the production of both white and blackheart malleable? During the war period, when shell noses of malleable iron were produced very commonly, a Government inspector undertook to get both from iron of the same composition. The white iron selected was annealed in the usual way, but one half of the casting was packed in oxidising material, *i.e.*, ore up to a mark, and the other half was packed in non-oxidising material, *i.e.*, boneash. When the castings were fractured one half showed perfectly whiteheart steel fracture, and in the other half a perfectly blackheart fracture. It may have been a freak, but it was demonstrated that it could be produced.

From the samples he had received from America he considered that an essential feature which distinguished the American blackheart from the English blackheart described in the Paper, was that, when examined under the microscope, it was found to have, in addition to the black velvety fracture, a good deal of pearlite in what Mr. Peace would say was a normal ferrite matrix. That, of course, increased its strength, but very much diminished its ductility, its capacity for elongation, and also, in his opinion, reduced its toughness, that is to say, the amount of bending and shock that it would stand. From what the author had said, it would appear that there was a rather critical point in the further heat treatment of blackheart malleable castings. They usually had the pure ferrite and the nodular graphite or free carbon, as it might be called, but if this metal was heated up to a suitable temperature some of that carbon would go back into solution, that is, revert to pearlite. Was that detrimental in cases where heat treatment had to be used? For example, in heating to the dull red heat which Mr. Peace said was usual in straightening certain castings which had to be fitted into jigs.

Defects of Blackheart.

American makers sometimes had difficulties through what they called unaccountable brittleness occurring in blackheart malleable iron. It occurred in various ways. If they galvanised a piece of blackheart malleable it became brittle; or under certain conditions, if they ground off some of the runner ends, they got it very brittle. Quite close to the hottest part of the metal there was a white steel fracture which was detrimental to this material, but a little bit further back, beyond the range where the grinding affected it, there was a true blackheart fracture.

Another thing was that sometimes when they riveted a piece of strained blackheart malleable, like a bracket, on to a girder, it was brittle, and factured through the rivet hole on cooling.

As far as he had been able to gather these slight disabilities of American blackheart seemed to indicate that it was in the range of blue heat (so called because of the colour of the oxide scale produced at this low temperature) that this brittle defect showed itself sometimes, but not always, in blackheart. Investigation seemed to show that it only happened when a certain amount of stressing had been previously put upon the metal, and perhaps Mr. Peace might tell them whether he had experienced that, and how he overcame it.

Mr. Peace had told them that American iron was preferable to English iron for making blackheart. He had some recollection that when they were at Derby Mr. Peace told some of them the reason for that lay in the different chromium content of the two irons, but perhaps he would confirm that view to them.

MR. SHERBURN seconded the vote of thanks, and observed that it was a very valuable Paper, containing so much information that it was difficult to appreciate it fully on the spur of the moment.

Early Beginnings.

The CHAIRMAN (Mr. S. G. Smith) said the fundamental principles of malleable cast iron were published by Boyden in 1822. Presumably it was whiteheart Mr. Peace had referred to Boyden as an American, who first made this blackheart in America. Boyden was, in fact, born in Staffordshire.

A man called Matthews, of Sheffield, patented a process in 1782 or 1783, 40 years before Boyden started his American foundry.

He wanted to ask a question which was supplemental to the questions Mr. Primrose had put. What was the difference between the American blackheart and the British or European blackheart, leaving out altogether the question of whiteheart?

Moulding Troubles.

MR. EVANS (Derby) said the chief troubles were pretty much the same in malleable as in ordinary grey iron. For instance, wet sand would cause a great deal of trouble, even more so than it would in the case of ordinary grey iron. The sand must be dry; also, the use of large quantities of new sand would lead to trouble.

In certain cases they would apply red sand to act as a chill. They would appreciate, therefore, that if they used a large quantity of red sand in the facing and tried to make a casting with this material they were not likely to succeed. There were well-known castings, straight flat round discs from 15 to 20 in. dia., which were made in malleable. The material might be of the correct composition, they might get super heat, but they were in for trouble if the facing sand was not suitable. To run successfully they had to make a core, cut in two sections. Generally speaking it wanted more careful controlling than was required with ordinary grey iron.

Since the members visited the works at Derby they had changed many of the methods, so he hoped a little later they would be able to repeat the visit.

They checked the weights of the feeders and runners. That was a point which needed to be controlled in malleable iron where the percentage of iron used to weight of castings produced was much higher than in an ordinary grey-iron foundry.

Essentials.

MR. PEACE said Mr. Primrose had mentioned several points as essential in casting blackheart malleable iron. Careful control of the composition of the iron by careful analysis of the material used, very careful moulding practice, and, in annealing, pyrometric control of the temperatures. He understood Mr. Primrose to say that it was impossible to make blackheart malleable without those factors. He himself did not go so far; it was possible to make blackheart malleable without having any analysis or taking temperatures for the annealing. But he was convinced that without careful control it was impossible to make it as set out in the paper.

A Common Base.

It was possible to make whiteheart out of blackheart composition, but it was practically impossible to make blackheart out of whiteheart

material. The reason was that the whiteheart always was high in total carbon and was nearly always very high in sulphur.

The Origin of the Black Fracture.

MR. PRIMROSE had made a point that the black fracture was effected by precipitating carbon when there was sufficient to make that fracture wholly black. They would see by the photographs that probably 75 per cent. of the material had no carbon; the fracture was black because the ferrite grains were so fractured that they did not reflect the light. It was possible to fracture blackheart so as to show a white fracture. This was accomplished by using a very heavy blow which shattered the crystals and they then had the ferrite crystals reflecting the light. He invited the members to inspect the fractures in the specimens exhibited.

The retention of pearlite in the skin, very close to the surface, he mentioned in the paper only casually, because at the present time they considered that they had practically remedied that trouble.

Effect of Subsequent Heat Treatment.

With regard to further heat treatment after annealing, it was essential to use pyrometric control. If they reached 730 deg. C. they would approach a brittle casting unless it was cooled at a rate not exceeding, say, 4 deg. C. per hour, which was hardly likely in works practice.

Mr. Primrose had referred to the embrittlement effect in galvanising, grinding and riveting. In galvanising it was purely a temperature effect, there was no question of strain. There seemed to be some critical point which had nothing to do with carbon content. Examined under the microscope it was just like normal blackheart, there was no difference. The fracture in this case was always intergranular instead of transgranular.

He thought it was a different problem from the grinding hardness Mr. Primrose mentioned, grinding embrittlement in this case being due to heating to 730 deg. C. In connection with riveting, the trouble arose from again a different cause. He had some malleable iron castings which had been riveted and split at the top. In his opinion that was due to excess of cold-working. Malleable was very subject to deformation, and if it was much cold-worked it would become brittle, but by re-heating it to 700 deg. C. and air-cooling or quenching it in water, that embrittlement could be remedied.

American and British Pig-Iron Compared.

In regard to the comparison of American pig-irons and English pig-irons, Mr. Primrose had said English pig-iron was not suitable. That was rather a strong statement. His firm used 2,000 to 3,000 tons per annum of English pig-iron for malleable. But they were not as useful as American irons if they were distined to be the sole pig-iron in the mixture. As far as his knowledge went it was due to the chromium content. He had never yet analysed common brands of English Hem. pig-iron with less than 0.02 per cent. chromium; in the American pig-irons he used the chromium content was never more than 0.01 per cent. The actual effect of that chromium content in the English irons was to restrain the decomposition of the carbide; and if put through the ordinary annealing process they found small nodules of free cementite which reduced the malleability.

He agreed with Mr. Smith that Boyden was an Englishman who came from Staffordshire, but he made his blackheart malleable in the United States by virtue of the fact that he used American pig-iron which had high manganese and low sulphur, and one could get this decomposition of the carbide of iron. He had heard of Matthews' process and had an idea that it was not a true blackheart process.

Essentially English and American blackheart were the same, as there could be only one good blackheart; and whilst the American foundries made it, and his firm made it also, he thought the Americans were rather casual in their methods.

In the paper he had not dealt with the size of the castings. The average size was probably about 10 to 28 lbs.

Oxidising packing materials were practically discontinued in blackheart making. There was no advantage to be gained from them. If a malleable casting were packed in sand it would anneal just as satisfactorily as if it were packed with other material.

Machine Fingers.

A MEMBER asked for Mr. Peace's opinion as to whether it was better to make agricultural machine fingers in whiteheart or in blackheart. He suggested that cracking might be prevented by heating up the mould and casting hot quickly. It would be found there was a considerable reduction in contraction.

MR. PEACE said it was not his wish to compare the two materials whiteheart and blackheart. He could say, however, that his firm had made millions of mowing machine fingers in blackheart, and were continuing to do so.

Hot Moulds.

In connection with cracking, if a mould was heated and then cast with blackheart iron, they got a grey casting. It was impossible to use a mould which had been made very hot. They had found that cracking could be prevented by proper gating. Perhaps heating the mould would be useful in whiteheart with its higher sulphur content, which did not have a great deal of effect in preventing annealing, but did have a great effect in preventing primary graphitising.

Replying to another question, MR. PEACE said resistance to corrosion was not due to the carbon content, but was due to the complete absence of carbon of any type in the skin. It was a well-recognised fact that pure iron did not rust. There was a process in which pure iron was deposited on the casting to prevent rusting. The point about blackheart malleable was that it had a composition which was practically pure iron. It contained probably silicon in solution up to 1 per cent. and a low manganese content—perhaps 0.3 per cent., which was generally recognised to be favourable for resisting corrosion.

MR. CAIRNS asked what would be (1) an approved composition of moulding sand for general casting, from a few ounces up to 2 cwt.? He knew that the temperature required with malleable iron was very much higher than with grey iron; (2) what was the difference between the running of a malleable mould and a steel mould? and (3) would not the same method of "feeding" apply to both?

The CHAIRMAN observed that by "black sand" Mr. Evans meant sand which had been used over and over again, but the bond had not been burned out quite. Whether dealing with heavy castings or with small ones, every precaution ought to be taken in each case to avoid those little "drawn" places.

MR. HOPWOOD asked whether Mr. Evans had ever come across cases of hot spots—that is, places on the casting that are grey in colour instead of white, through the mould becoming locally heated by a large quantity of metal passing over that place.

MR. EVANS replied that he had, and the remedy was to chill the places affected. It was possible to get grey and white iron castings on the same runner.

Coal-Dust.

MR. SHERBURN said he was interested in Mr. Peace's statement that in the United States the consumption of malleable cast iron per head of population was ten times more than in this country. There must be some reason for that, and perhaps Mr. Peace would tell them what it was.

Perhaps the members of the Branch generally were not very competent to go deeply into the question of malleable castings, but it had struck him that the ordinary ironfounder could profit very much from hearing a Paper of this kind, and observing the processes to which attention was called. He might derive from it many lessons in regard to shrinkage and other difficulties which he was up against in his own practice.

He would like some information to be given with regard to the pulverising plant. When they visited the works at Derby, particulars were given of the size of grain into which the coal was

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broken up by the pulverisers, and it had occurred to him that machines of this type might solve the coal-dust problem for the foundryman, and ensure more uniformity in grain size than the methods at present secured. Coal-dust was a very variable article at present; those who had taken the trouble to test the grain size of samples from various consignments knew perfectly well that was the case. It impressed itself upon him that this method of pulverising coal might provide coal-dust of uniform quality in regard to grain size. Foundrymen were up against the lack of uniformity in raw materials, and it would be an advantage to secure some uniformity in this matter.

Another question he asked referred to the amount of breakage occurring in the cleaning process. He believed Mr. Peace's firm rumbled their castings in the hard condition. Had they any special method of safeguarding against such breakages?

Consumption per Capita.

MR. PEACE said the greater consumption of malleable per head of population in America was, he believed, due to the fact that the qualities of malleable were not sufficiently recognised in this country, and people were rather chary of specifying material which they thought unreliable. It was quite reliable if properly made, and that it was properly made could be gathered from the list of rejections by customers which he had on exhibit.

The cleaning plant included sand-blast barrels, and also a hand-operated sand-blast. This was used on castings which were of such design that they had internal stresses set up on cooling. It was only the stronger section castings which were rumbled. Very little breakage occurred during rumbling; that was due to the iron being really strong, owing to its low carbon content. It was not like the ordinary white iron from the cupola, which was more brittle, due to higher carbon content.

MR. CAIRNS asked whether Mr. Evans used any mould dressing in order to get a clear skin on the casting.

MR. EVANS stated that no dressing of moulds of any description was used.

The CHAIRMAN remarked that the temperature of the metal for malleable castings could not be compared with that of steel castings of the same size. The size made all the difference to the "eating in" or part-fusion of the sand.

Discussion by East Midlands Foundrymen.

DR. BRAMLEY asked if the author would elaborate on his remarks as to the part sulphur played in the annealing of whiteheart castings.

MR. PEACE replied that in whiteheart malleable the sulphur is always unbalanced in reference to the manganese, this being practically essential to guarantee original hard iron castings free from graphite. Variations in sulphur content do not appear seriously to affect annealing of whiteheart providing the silicon is sufficiently high, but with low silicon-content increasing sulphur will appreciably retard the annealing.

Obtaining Low Carbon.

MR. RUSSELL said he was interested to hear of the difference in the pig-irons, and of the necessity for the carbon-content being kept low, and inquired if this was achieved by merely buying low carbon pig-irons, or was the carbon reduced in the air furnace melting.

In reply the author said the pig-irons purchased for blackheart manufacture are by no means low in carbon. Being low sulphur grey hematite irons the reverse is the case, 3.80 to 4.00 per cent. being common figures. As the charge contains about 50 per cent. of shop scrap which is low carbon, the actual carbon content of the mixture charged is around 3.00 per cent. On melting in the air furnace this carbon content is reduced to about 2.50 per cent. The loss varies with the furnace design and the blast which is used. Occasionally steel scrap is included in the charge to reduce the carbon content.

MR. GOODWIN said the author had stated that a ¾-in. section would be a thick section to make in whiteheart. He, personally, could not see any difficulty in annealing sections up to 3 in. He would, however, agree that there was a great difference in the "machineability." In his (Mr. Goodwin's) opinion, the reason whiteheart had not its share of the market was that the whiteheart founders did not appreciate the value of the works chemist to a proper extent, and a great number of firms making whiteheart castings left everything to the foreman.

MR. PEACE insisted that there was perhaps some disagreement as to what is satisfactorily annealed whiteheart, and whilst he agreed a 3-in. section could be annealed to an extent which would give it fair resistance to shock, it is doubtful if it would possess the property of "malleability" to any degree. Mr. Goodwin was undoubtedly correct in saying that the whiteheart industry is suffering from adherence to "rule of thumb" methods, and that standardisation and greater scientific control of the composition and of the annealing temperatures would, by producing a more reliable product, greatly increase the market for whiteheart.

MR. PEACE, in answer to a question by MR. DRIVER, said that the "scrap" used in the manufacture of malleable cast-iron was the runners, gates and feeders and other shop scrap from the malleable foundry itself. Any annealed scrap castings are consumed and ordinary carbon steel scrap is used to a slight extent. The utilisation of ordinary scrap cast-iron is impossible in making malleable. Answering a further query by MR. HAMMOND, the author stated that the steel is usually melted straight into the mixture when the quantity necessary is small, say not above 7 or 8 per cent., but in some instances it has been used alloyed with pig or other iron in the form of a low carbon pig-iron.

Heat Treatment Limitations.

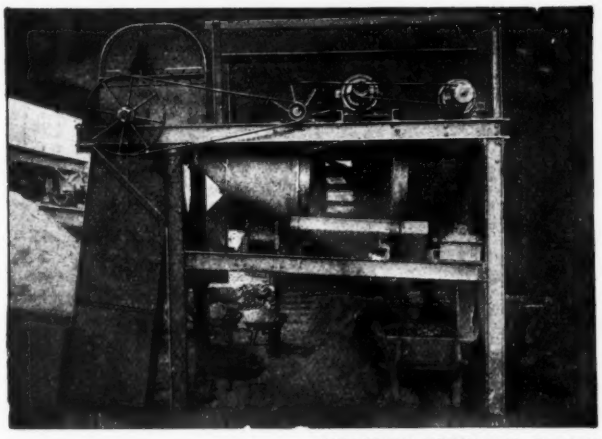
MR. HAMMOND said blackheart castings could not be double annealed, but a 3-in. section in whiteheart would stand three annealings, and inquired if it were possible to make a 3-in. section in blackheart perfectly sound, and also if, in blackheart annealing, a period for soaking was taken. He (Mr. Hammond) was sure that one of the reasons for the comparative shortcomings of whiteheart was due to melting in the cupola, as against melting in the air furnace, but if the cupola was properly run accurate results could be obtained indefinitely. If the whiteheart founders would take the proper scientific interest it would be found quite possible to get as uniform results from the cupola as from the air furnace.

MR. PEACE thought that if a section of whiteheart was annealed three times there would almost certainly be a penetration in the skin of iron oxide with possible peeling. It was quite possible with suitable gating and feeding to make a 3-in. section in blackheart perfectly sound. As regards the possibility of getting as uniform results from the cupola as from the air furnace—with carefully standardised cupola practice it might be thought that such a possibility could be made a reality, but experience shows that there are more variables in cupola melting than in air furnace.

In reply to MR. DRIVER, who asked what was the most economical section for the designer to aim at—were there any thicknesses which would give the cheapest casting, MR. PEACE pointed out that there was no general economical section for the designer to adopt, each job would require consideration on its own merits. Uniformity of section is certainly a factor to be aimed at in designing malleable castings. Perhaps the most common section found in malleable is ⅜ in. to ½ in. In answer to a query by MR. LUCAS as to the best method of obviating distorted casting, MR. PEACE referred to his Paper, wherein it was stated that any method of heating blackheart malleable castings which cannot be carefully controlled pyrometrically was dangerous. A coke fire should not be used as carbon would be absorbed. Unless a furnace was available with pyrometric equipment, it was better to return the distorted castings to the manufacturer.

MR. J. W. JENKINS and Mr. W. H. Fradd have been elected directors of John Williams & Sons (Cardiff), Limited.

A REVELATION TO IRONFOUNDERS



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Trade Talk.

WORK IS BEING RESUMED at the Elba Steel Works, Gowerton.

THE BLAST FURNACE of M. & W. Grazebrook, Limited, Netherton, Dudley, which has been idle since July owing to the coal strike, has been restarted.

A LECTURE WAS GIVEN TO members of the Sheffield Foundry Trade Technical Society on November 29 at the Department of Applied Science by Dr. P. Longmuir on "Foundry Metallurgy." Mr. J. Sandford presided.

THE GRINDING AND PULVERISING OFFICES of International Combustion, Limited, 11, Southampton Row, London, W.C., report orders for three Hardinge and eight Raymond mills, and one Gayco air separator, the destinations being works in Great Britain, India, and France.

THE SECRETARY of Leyland Motors, Limited, states that the various rumours that have appeared recently suggesting that negotiations are taking place with a view to the fusion or amalgamation of that company with certain other well-known motor-vehicle manufacturers are without foundation.

A LECTURE ON "The Internal-Combustion Engine, with Special Reference to the Gas Turbine," was given at the November meeting of the Sheffield Society of Engineers and Metallurgists in the Mappin Hall, Department of Applied Science, by Professor G. F. Charnock, of Bradford. The president (Mr. A. Senior) was in the chair.

OVER 120 MEMBERS OF Newcastle and District Branch of the Institute of British Foundrymen accepted an invitation to inspect William Doxford & Sons' works at Sunderland recently. They later met under the presidency of Mr. E. Wood, at the Technical College, when Mr. F. Allan, of Sunderland a member, read an instructive paper entitled "Common Troubles of the Ironfounder."

JOHN CASHMORE, Great Bridge, Staffs, have purchased for dismantling and breaking up the old-established concern of John Turton & Sons (Vulcan Forge and Rolling Mills), Limited, of Sheffield, and have already commenced on this work. The firm have also commenced dismantling the works of Roberts & Cooper, Limited, Bromley Ironworks, Brierley Hill, this being one of the well-known concerns of the district many years ago.

THE BURNTISLAND SHIPBUILDING COMPANY, LIMITED, have secured orders to build a cargo steamer of 7,500 tons dead-weight for Cardiff owners, a cargo steamer of 9,000 tons dead-weight for London owners, also one of 1,000 tons for Glasgow owners. The propelling machinery, consisting of engines and boilers, for the two larger contracts will be supplied by David Rowan & Company, Limited, Glasgow, and for the 1,000-ton steamer by William Beardmore & Company, Limited, Coatbridge.

A MEETING OF THE HOLDERS of the 5 per cent. (income-tax free) first debenture stock of the Barrow Hematite Steel Company, Limited, was held in London, at which a resolution was passed permitting the company "to make such arrangements with its bankers or others as the directors may decide regarding existing loans or any future loans, including the issue, by way of security or otherwise, to such bankers or others of the £219,607 first debenture stock authorised by resolution of the first debenture stockholders passed on the 25th day of June, 1926." Sir W. B. Peat presided.

THE COMMITTEE of the London Iron and Steel Exchange have under consideration the question of opening the Exchange daily for the use of the members. This would necessitate finding fresh premises which, it is suggested, should include provision for luncheon accommodation, writing and smoking rooms. It has been pointed out that much time and money now expended upon telephone calls, waiting for interviews, etc., would be saved if members could rely upon meeting their customers daily at such an institution. Before going further into this scheme, however, the Committee wish to obtain the views of the members, and are canvassing the members accordingly.

THE GREAT WESTERN RAILWAY COMPANY has placed the following contracts: 35-ft. turntable for Newton Abbot (Ransomes & Rapier, Limited, Ipswich); six 100-k.v.a. single-phase transformers for Park Royal Generating Station (Metropolitan-Vickers Electrical Company, Limited, 4, Central Buildings, S.W.1); transit shed at King's Dock, Swansea (Sir William Arrol & Company, Swansea, Limited, King's Works, Swansea); two 5-ton and two 6-ton electric cranes for South Quay, Newport Docks (Stothert & Pitt, Limited, Bath); overhaul of steam hopper barge (Sir Ernest Palmer; Harris Brothers, Limited, Swansea); overhaul of tug "Wolfhound" (the Tredegar Dry Dock Company, Limited, Newport, Mon.); overhaul of tug "Archibald Hood" (Thomas Diamond & Company, Limited, Cardiff); overhaul of s.s. "Sir Walter Raleigh" (Thos. Bickle Engineering Company, Plymouth).

THE HOSKINS IRON AND STEEL COMPANY, LIMITED, have secured £300,000 additional capital to finance the establishment of new works and plant at Port Kembla (N.S.W.). An issue of 7½ per cent. cumulative preference shares has been underwritten. There are already in existence 22,000 10 per cent. preference shares, which take priority over the present issue. The assets of the company are estimated to exceed liabilities by approximately £1,900,000, so that with additional capital the excess of assets would amount to about £2,200,000, which would make the present issue of preference shares well secured. The profits for the past five years at Lithgow are said to have averaged £105,000 a year.

MR. H. J. SKELTON, in a letter to "The Times" on the question of the steel industry, points out that there is a slow supersession of the older type of blast furnaces taking place in this country, and that, while the erection of new furnaces is undesirably slow, yet there are hundreds of blast furnaces which in all probability will never be relit, owing to their situation or equipment rendering them quite unfit for economic production under modern conditions. The number of furnaces idle, as quoted by the Home Secretary, is no doubt correct, and due to the fact of insufficient fuel supply among other things. Our difficulties in the iron and steel trade are very great, and it will probably take a few years to establish something like an equilibrium. In the meantime it is well that we should view the silent revolution that is going on in the economic position of the British iron and steel trade with a due sense of proportion. Many of our great steelworks have been re-equipped, modernised, and are well fitted to take advantage of any improvement that may arise in the general trade position. At the same time one of the greatest difficulties that he foresees as a hindrance to prosperity is the cost of transport and handling. It will, no doubt, be a very unpalatable fact for the directors of railway companies, for example, to have to tell their shareholders that they have lost considerable revenue from low-priced heavy industries by reason of the fact that such industries were unequal to economic continuance owing to the incidence of increased transport charges. As a result of over 50 years' experience he has noticed that every big strike or lock-out has the effect of precipitating the collapse of enterprises that are unfit for economic continuance.

Contracts Open.

Andover, December 18.—3-in. and 6-in. heavy cast-iron spigot and socket water pipes, valves, hydrants and specials, for the Town Council. Mr. R. W. Knapp, borough surveyor, Andover.

Budleigh Salterton, December 17.—A 40-b.h.p. crude oil engine, for the Budleigh Salterton Urban District Council. Mr. J. B. Holland, Council Offices, Budleigh Salterton.

Johannesburg, January 20.—Twelve cast-iron 10,000-gallon tanks without trunks (Tender No. 194), for the South African Railways and Harbours. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Ref. A.X. 3912.)

Stockton-on-Tees, December 11. — (4) Bolts and nuts; (5) castings; (7) cast-iron S. and S. pipes; (10) wrought-iron tubing; and (11) gasmeters, during six months ending June 30, 1927, for the Corporation. Mr. W. W. Atley, engineer and general manager, Corporation Gasworks, Thompson Street, Stockton-on-Tees.

New Companies.

Allbright Castings, Limited.—Capital £5,000 in £1 shares. Directors: C. E. Metham, 47, Calthorpe Road, Birmingham; and F. Turner, 43, Waterloo Street, Birmingham.

E. O. French, Limited, 44, Earl Street, Coventry.—Capital £10,000 in £1 shares. Metal dealers. Directors: E. O. French, Mrs. E. G. French and Mrs. M. Robson.

Harris & King, Limited, Protector Foundry, Tipton, Staffs.—Capital £100 in £1 shares. Ironfounders. Directors: H. C. Harvey and A. H. Powis.

B. K. Morton & Company (1926), Limited.—Capital £10,000 in £1 shares, to acquire business of iron and steel merchants and manufacturers, carried on by G. H. Skellington, G. H. G. Skellington and A. Hartley, at Princess Street, Sheffield, as B. K. Morton & Company, Limited. Directors: G. H. Skellington, 66, Clarke Grove Road, Sheffield; A. Hartley, 61, Burcot Road, Sheffield; and G. H. G. Skellington. Secretary: T. T. Pinder.

D. R. Tomlinson & Company, Limited, 66, Sparling Street, Liverpool.—Capital £2,000 in 1,500 ordinary and 500 6 per cent. cumulative preference shares of £1. Iron merchants. Directors: D. R. Tomlinson, A. J. Monks, F. J. Randle and W. J. Jump.

IT REALLY IS GOOD!

Our Gauister doesn't just happen to be better—

IT'S MADE BETTER

(we make it)

It's made with high grade ingredients and care,— mixed with skill, experience, and a little water
It's ready for use,—any body can apply it—it's cheap & good.

WRITE TO
The General Refractories Co Ltd
SHEFFIELD
OR to their Monomark— BCM/GRC · LONDON

Great this pen-this nibs for the paper is a tough job!

73/28

IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—Now that peace is practically restored in the coalfields, and future fuel supplies are assured for industrial operations, ironmasters throughout the Tees-side area are pushing forward preparations for relighting blast furnaces, which, it is now confidently anticipated, may be in full blast for production by the end of the year. The vital factor in this connection is the price of coke. At the moment furnace coke is being offered under contract at something like 30s. per ton delivered at works, but this is really an impossible figure, if pig-iron is to be sold competitively. Sellers of pig-iron have been offering No. 3 G.M.B. at 85s. per ton over two months from the resumption of work at the furnaces, but obviously this must be an unremunerative figure if producers have to pay 30s. per ton for their coke. In the market there is practically no business passing, and quotations are about as follow:—No. 1, 117s. 6d.; No. 3 G.M.B., 112s. 6d.; No. 4 foundry, 111s. 6d.; No. 4 forge, 111s. per ton.

The North-East Coast market for hematite is also subject to the conditions governing that for foundry pig, and consequently it must be some weeks before full production can be attained. In the meantime forward business is at a standstill, with quotations nominal at about 87s. 6d. to 90s. for delivery over the first quarter of the New Year. On the North-West Coast prices are steady, with Bessemer mixed numbers quoted at £4 19s. 6d. per ton delivered at Glasgow, £5 2s. 6d. per ton delivered at Sheffield, and £5 7s. 6d. to £5 17s. 6d. per ton delivered at Birmingham.

The shipments of pig-iron from the port of Middlesbrough during November only amounted to 1,141 tons—235 tons coastwise and 906 tons abroad—as compared with 3,069 tons in October—290 tons coastwise and 2,779 tons abroad—a decrease of 1,928 tons.

LANCASHIRE.—In the interval that must necessarily elapse before furnace plants are again in full producing activity, local consumers of foundry pig are holding off buying, and prices are in a somewhat indefinite position. For forward deliveries of Scottish No. 3, for example, delivered into the Manchester district, about £5 10s. per ton has been asked recently, with Middlesbrough at roughly 10s. less than this figure.

THE MIDLANDS.—Some of the Derbyshire furnaces, it is reported, are in a more forward condition for restarting promptly than the more northern plants, but in any event there is unlikely to be any quantity of iron available this side of the New Year. Meanwhile Middlesbrough No. 3 has been reduced by 2s. 6d. per ton for prompt despatch, making the figure delivered here about £6 12s. 6d. There is still some Lincolnshire No. 3 offered here at £5 to £5 2s. 6d. per ton for January delivery.

SCOTLAND.—Due to the approach of the end of the year, consumers are naturally disinclined to discuss future commitments in pig-iron, and the business transacted on 'Change is purely nominal. There has not been any great amount of English iron booked on Scotch account, as there is a lot of the foreign iron to come through, and many consumers have committed themselves for this class of iron up to the end of January. Some of the English furnaces are suggesting the uniting of old contracts with new sales, and in a number of instances this is being done.

Finished Iron.

Active preparations are being made for a restart at the iron mills, and it is probable that those works that have stocks of puddled bars will be employed before Christmas. With a view to testing markets prices have been put forward, varying from £12 10s. to £13 for crown quality, with 25s. per ton less for nut and bolt iron.

Metals.

Copper.—Conditions in the standard copper market, on the whole, may be reported as fairly steady, although it must be admitted values remain at comparatively low levels. The general industrial outlook, however, seems to be improving slowly, and copper is relatively cheap.

Official closing prices of standard copper have been as follow :—

Cash : Thursday, £56 12s. 6d. to £56 15s.; Friday, £56 12s. 6d. to £56 15s.; Monday, £57 to £57 2s. 6d.; Tuesday, £57 7s. 6d. to £57 10s.; Wednesday, £57 7s. 6d. to £57 10s.

Three Months : Thursday, £57 7s. 6d. to £57 10s.; Friday, £57 7s. 6d. to £57 10s.; Monday, £57 15s. to £57 17s. 6d.; Tuesday, £58 2s. 6d. to £58 5s.; Wednesday, £58 2s. 6d. to £58 5s.

Tin.—Values of standard metal in this section of the market continue on an upward tendency, following the temporary setback in the previous week. American buying, together with repurchases by the short interest, have added to the buoyancy of the market, while there has been a very good demand for actual tin on the spot, the price of which was taken up several pounds. There is a renewed decrease in the Liverpool stock, but some tin went into stock in London, though the increase on balance between the two ports is only slight.

Official closing prices of standard tin have been as under :—

Cash : Thursday, £313 10s. to £313 15s.; Friday, £314 5s. to £314 10s.; Monday, £313 15s. to £314; Tuesday, £310 5s. to £310 10s.; Wednesday, £309 5s. to £309 10s.

Three Months : Thursday, £298 15s. to £299; Friday, £299 10s. to £300; Monday, £299 10s. to £299 15s.; Tuesday, £298 15s. to £299; Wednesday, £298 15s. to £299.

Spelter.—The termination of the prolonged labour trouble has stimulated market views of a speedily increased consumptive demand for ordinary spelter, but for the time being buying is still limited to more immediate requirements; nor does it appear probable that any marked change will be experienced over the remainder of the year.

The following are the week's prices :—

Ordinary : Thursday, £33 2s. 6d.; Friday, £33 1s. 3d.; Monday, £33 2s. 6d.; Tuesday, £32 18s. 9d.; Wednesday, £32 16s. 3d.

Lead.—The market for soft foreign pig remains in an unsatisfactory position, although the change in the labour outlook may probably have a beneficial influence in the near future. Values have been weak again under the heavy arrivals, and a poor demand from consumers, while supplies threaten to continue in excess of current needs at least for some time.

The week's prices are appended :—

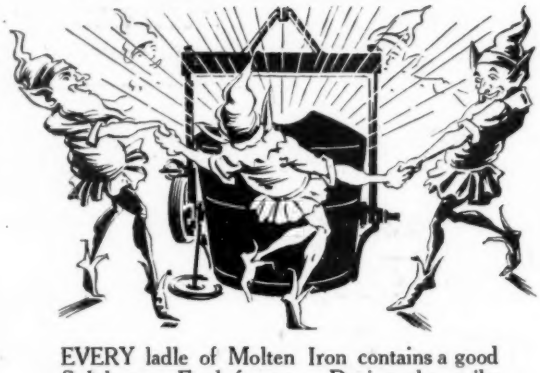
Soft foreign (prompt) : Thursday, £29 15s.; Friday, £28 16s. 3d.; Monday, £28 15s.; Tuesday, £28 13s. 9d.; Wednesday, £28 15s.

We are the

SUPERFLUX

SPRITES

(WE FEED ON SULPHUR).



EVERY ladle of Molten Iron contains a good Sulphurous Feed for us. During the strike we have grown VERY fat on Sulphur from Foreign Coke. Every class of Ironfounder has blessed us. Superflux is always safe and sure.

USE SUPERFLUX AND BE SURE

MADE ONLY BY—

SHEFFIELD FOUNDRY SUPPLIES CO.,

PALM TREE WORKS,

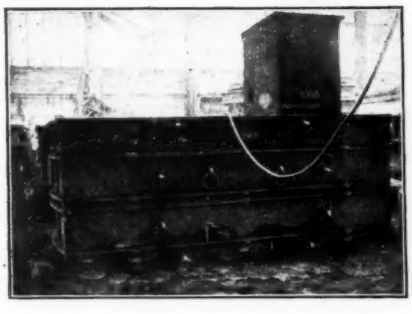
Staniforth Road,————SHEFFIELD.

FUEL

has lately been, and will most essentially be for some time to come, an expensive necessity in the foundry, and savings in this direction are always of the greatest importance.

It is therefore imperative that there should be no waste, and that all fuel used should be burned in a most scientific and economical manner and its full calorific value obtained.

OEHM'S HEATING ELEMENT



is an apparatus designed expressly for the efficient combustion of low grades of fuel. Its use will enable you to reduce your production costs. All users of OEHM'S HEATING ELEMENTS are showing large savings in their fuel bill—in some cases more than £1,000 annually.

This surely must appeal to you and merit your immediate investigation. Write us to-day for full particulars of our trial offer.

OEHM'S HEATING ELEMENTS

CONSTRUCTED BY

BRITISH DRYING & HEATING CO. Ltd.,
14, WATERLOO PLACE - LONDON - S.W.1.

Telegrams: Britdriet, Piccy, London. *Telephone: Gerrard 4850.*

BRITISH D&H COMPANY LTD

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	57	7	6
Three months ..	58	2	6
Electrolytic	64	5	0
Tough	62	10	0
Best selected ..	63	5	0
Sheets	92	0	0
India	73	10	0
Wire bars	64	15	0
Do. December ..	64	10	0
Do. January ..	64	10	0
Ingot bars	64	10	0
H.C. wire rods ..	69	0	0
Off. av. cash, Nov.	57	7	1 5/32
Do., 3 mths. Nov.	58	3	11 15/16
Do., Sttlmnt Nov.	57	6	11 3/16
Do., Electro, Nov.	65	16	0 3/16
Do., B.S., Nov.	64	7	6
Aver. spot price copper, Nov. ..	57	7	1¼
Do., wire bars, Nov.	66	1	0¼
Solid drawn tubes			13d.
Brazed tubes ..			13d.
Wire			9½d.

BRASS.

Solid drawn tubes ..	12d.
Brazed tubes	13½d.
Rods, drawn	11½d.
Rods, extd. or rlld. ..	7½d.
Sheets to 10 w.g ..	10½d.
Wire	10½d.
Rolled metal	9¾d.
Yellow metal rods ..	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets ..	8½d.

TIN.

	£	s.	d.
Standard cash ..	309	5	0
Three months ..	298	15	0
English	307	5	0
Bars	310	0	0
Straits	319	15	0
Australian	314	10	0
Eastern	308	10	0
Banca	319	5	0
Off. avr. cash, Nov.	309	9	1 17/20
Do., 3 mths., Nov.	298	14	9 15/16
Do., Sttlmt. Nov.	309	8	2 5/16
Aver. spot., Nov.	309	9	1¾

SPELTER.

Ordinary	32	16	3
Remelted	32	12	6
Hard	27	0	0
Electro 99.9 ..	35	10	0
English	33	12	6
India	30	0	0
Zinc dust	43	0	0
Zinc ashes	15	0	0
Off. aver., Nov. ..	33	9	8 11/16
Aver., spot, Nov.	33	9	10

LEAD.

Soft foreign ppt.	28	15	0
English	30	5	0
Off. average, Nov.	29	8	3 29/64
Average spot, Nov.	29	5	4¾

ZINC SHEETS, &c.

Zinc sheets, English	42	10	0
Do. V.M. ex whf.	39	10	0
Rods	45	0	0
Boiler plates ..	39	0	0
Battery plates ..	38	10	0

ANTIMONY.

Special brands, Eng.	74	10	0
Chinese	57	0	0
Crude	36	0	0

QUICKSILVER.

Quicksilver ..	17	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon —			
25%	9	5	0
45/50%	11	5	0
75%	17	10	0
Ferro-vanadium—			
35/40%	14/3 lb. va.		
Ferro-molybdenum—			
70/75% c. free ..	5/– lb.		
Ferro titanium—			
23/25 % carbonless	11½d.		
Ferro-phosphorus, 20/25%,	£17	0	0
Ferro-tungsten—			
80/85%, c.fr. ..	1/5½ lb.		
Tungsten metal powder—			
98/99% ..	1/10 lb.		
Ferro-chrome—			
2/4% car. ..	£32	0	0
4/6% car. ..	£23	5	0
6/8% car. ..	£21	15	0
8/10% car. ..	£20	12	6
Ferro-chrome—			
Max. 2% car.	£36	0	0
Max. 1% car.	£42	0	0
Max. 0.70% car.	£54	0	0
70%, carbonless	1/5 lb.		
Nickel—99%, cubes or pellets ..	£170		
Cobalt metal—98/99%	8/3 lb.		
Aluminium 98/99%	£104		
Metallic Chromium—			
96/98% ..	3/– lb.		
Ferro-manganese (net)—			
76/80%, loose	£16	0	0
76/80%, packed	£17	0	0
76/80%, export	£16	0	0
Metallic manganese—			
94/96%, carbonless	2/– lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten ..	2	6
Finished bars, 18% tungsten ..	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over .. 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Do. under ¼in. to ⅛ in. .. .. 1/– lb.
Flats, ½in. × ¼in. to under 1 in. × ⅛ in. 3d. lb.
Do. under ½in. × ¼in. 1/– lb
Bevels of approved sizes and sections 6d. lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—

Scrap pieces .. .. 3d.
Turnings and swarf 1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel	3	2	6 to 3	10	0	
Bundled steel & shrngs. ..	2	7	6			
Mixed iron & steel	2	15	0 to 3	0	0	
Heavy cast iron	2	15	0 to 2	17	6	
Good machinery for foundries	3	3	6 to 3	10	0	
Cleveland—						
Heavy steel ..	3	2	6			
Steel turnings ..	2	7	6			
Cast iron borings	2	5	0			
Heavy forge ..	4	2	6			
Bushelled scrap	3	10	0			
Cast-iron scrap	3	13	6 to 3	17	6	
Lancashire—						
Cast-iron scrap	3	10	0			
Hvy. wrought ..	3	2	6			
Steel turnings ..	1	17	6			

London — Merchants' buying prices delivered yard.

Copper (clean)..	48	0	0
Brass (clean) ..	38	0	0
Lead (less usual draft)	26	0	0
Tea lead ..	22	0	0
Zinc	23	0	0
New aluminium cuttings ..	82	0	0
Braziery copper	44	0	0
Gunmetal ..	47	0	0
Hollow pewter	190	0	0
Shaped black pewter ..	140	0	0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—	
Foundry No. 1 ..	117/6
Foundry No. 3 ..	112 6
Foundry No. 4 ..	111 6
Forge No. 4	111/–
Hematite No. 1 ..	—
Hematite M/Nos. ..	87/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	—
„ d/d Birm. ..	—
Midlands—	
Staffs common* ..	—
„ No. 4 forge ..	—
„ No. 3 foundry	—
Shrops. basic	—
„ Cold blast, ord.*	—
„ „ roll iron* ..	—
* d/d Birmingham.	
Northants forge	—
„ fdry No. 3 ..	85/–
Derbyshire forge ..	—
„ fdry. No. 3 ..	88/9
„ basic	—
Scotland—	
Foundry No. 1 ..	—
„ No. 3 ..	117/6
Hem. M/Nos. ..	—
Sheffield (d/d district)—	
Derby forge	—
„ fdry. No. 3 ..	—
Lincs. forge	—
„ fdry. No. 3 ..	—
E.C. hematite	—
W.C. hematite ..	—
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3.. ..	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
„ fdry. No. 3 ..	—
Northants foundry No. 3	—
Dalzell, No. 3	132/6
Summerlee, No. 3 ..	132/6
Glengarnock, No. 3 ..	—
Gartsherrie, No. 3 ..	132/6
Monkland No 3	132/6
Coltness, No. 3	132/6
Shotts, No. 3	132/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.) nom. ..	12	10	0 to 16	0	0	
Angles			—			
Tees to 3 united ins.			—			
Nut and bolt iron			—			
Hoops	14	10	0			
Marked bars (Staffs.) f.o.t. ..	14	10	0			
Gas strip	12	10	0			
Bolts and nuts .. ¾ in. × 4 in. ..	15	5	0			
Steel—						
Ship plates	8	12	6			
Boiler plts. ..	11	5	0			
Chequer plts. ..	9	15	0			
Angles	7	17	6			
Tees	8	17	6			
Joists	7	17	6			
Rounds and Squares 3 in. to 5½ ins. ..	8	10	0			
Rounds under 3 in. to ¾ in. (Untested)	9	0	0 and upwards			
Flats, over 5 in. wide and up ..	9	10	0			
Flats, 5in. to 1½in.	8	10	0			
Rails, heavy ..	8	10	0			
Fishplates	12	10	0			
Hoops (Staffs.) ..	10	10	0			
Black sheets, 24g.	12	12	6			
Galv. cor. sheets, 24g.	17	10	0			
Galv. fencing wire 8g. plain	12	10	0			
Billets, soft	7	0	0 to 7	5	0	
Billets, hard ..			—			
Sheet bars	7	10	0			
Tin bars d/d.. ..	7	10	0			

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to 10 w.g. ..	1	3½
Wire	1	4
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/– to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	23.26
No. 2 foundry, Valley	19.00
No. 2 foundry, Birm.	20.00
Basic	20.26
Bessemer	21.76
Malleable	20.76
Grey forge	20.26
Ferro-mang. 80% d/d	100.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	2.00
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.50
Sheets, black, No. 24..	3.00
Sheets, galv., No. 24 ..	3.85
Sheets, blue an'l'd, 9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
„ furnace	—
Durham & North.	
„ foundry	—
„ furnace	30/–
Other Districts, foundry	—
„ „ furnace (basis)	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	24/6
„	28×20, „	49/–
„	20×10, „	—
„	18¾×14, „	—
C.W.	20×14, „	—
„	28×20, „	—
„	20×10, „	—
„	18¾×14, „	—

Terneplates 28×20, — per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£18/10 to £19/0
Rolled Ord.	£15/10/0 to £16
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12
Pig-iron	£6 0 0 to £6 10 0

all f.o.b. Gothenburg

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas ..	60%	.. 50%
Water ..	55%	.. 45%
Steam ..	50%	.. 40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Dec. 2	56	12	6	No change
,, 3	56	12	6	,, ,,
,, 6	57	0	0	inc. 7/6
,, 7	57	7	6	,, 7/6
,, 8	57	7	6	No change

Electrolytic Copper.

	£	s.	d.	
Dec. 2	64	0	0	No change
,, 3	64	0	0	,, ,,
,, 6	64	0	0	,, ,,
,, 7	64	5	0	inc. 5/-
,, 8	64	5	0	No change

Standard Tin (Cash).

	£	s.	d.	
Dec. 2	313	10	0	dec. 20/-
,, 3	314	5	0	inc. 15/-
,, 6	313	15	0	dec. 10/-
,, 7	310	5	0	,, 70/-
,, 8	309	5	0	,, 20/-

Tin (English ingots).

	£	s.	d.	
Dec. 2	311	10	0	dec. 20/-
,, 3	312	5	0	inc. 15/-
,, 6	311	10	0	dec. 15/-
,, 7	308	0	0	,, 70/-
,, 8	307	5	0	,, 15/-

Zinc Sheets (English).

	£	s	d.	
Dec. 2	42	10	0	No change
,, 3	42	10	0	,, ,,
,, 6	42	10	0	,, ,,
,, 7	42	10	0	,, ,,
,, 8	42	10	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
Dec. 2	33	2	6	dec. 1/3
,, 3	33	1	3	,, 1/3
,, 6	33	2	6	inc. 1/3
,, 7	32	18	9	dec. 3/9
,, 8	32	16	3	,, 2/6

Lead (English).

	£	s.	d.	
Dec. 2	30	5	0	No change
,, 3	30	5	0	,, ,,
,, 6	30	5	0	,, ,,
,, 7	30	5	0	,, ,,
,, 8	30	5	0	,, ,,

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9½
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	—	7 6 5½

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